CONFERENCES

IMPERIAL AGRICULTURAL RESEARCH CONFERENCE, 1927.

Agricultural Research

in the

Overseas Empire.

IMPERIAL BUREAU
1 JUNE 1928
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Issued by the Organising Committee of the Conference.

10, Whitehall Place,
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This account of Agricultural Research in the Overseas Empire has been compiled from reports supplied by the different Governments.

In order to produce a volume of reasonable size and cost it has been necessary to summarise the information given: as a result much that is of interest and value has had to be omitted.

In the work of summarising regard has been had to the relative importance of the different countries from the point of view of agricultural production and population as well as from that of the amount of research carried out.

An exception has been made in the case of India: a specially printed publication by the Indian Government is separately issued to the Conference: the summary of Indian agricultural research is accordingly relatively brief.

AGRICULTURAL RESEARCH IN THE OVERSEAS EMPIRE.

CANADA.

Federal Department of Agriculture.

Research work in agriculture is carried on to a considerable extent in four of the branches of the Federal Department of Agriculture, namely, the Experimental Farms Branch, the Health of Animals Branch, the Entomological Branch, and the Dairy and Cold Storage Branch.

Experimental Farms Branch.

Research work in the Experimental Farms Branch is carried on at the central farm and at all the branch farms and stations. The Central Experimental Farm is at Ottawa. The branch farms and stations are :—

Prince Edward Island—Experimental Station, Charlottetown ; Experimental Fox Ranch, Summerside.

Nova Scotia—Experimental Farm, Nappan ; Experimental Station, Kentville.

New Brunswick—Experimental Station, Fredericton.

Quebec—Experimental Stations at Cap Rouge, Lennoxville, St. Anne de la Pocatière, and La Ferme ; Tobacco Experimental Station, Farnham ; Experimental Sub-station, Saguenay County.

Ontario—Experimental Stations at Kapuskasing and Harrow.

Manitoba—Experimental Farm, Brandon ; Experimental Station, Morden.

Saskatchewan—Experimental Farm, Indian Head ; Experimental Stations at Rosthern, Scott, and Swift Current.

Alberta—Experimental Stations at Lacombe and Lethbridge ; Experimental Sub-stations at Beaverlodge and Fort Vermilion; Buffalo Park, Wainwright.

British Columbia—Experimental Stations at Invermere and Summerland ; Experimental Farm, Agassiz ; Experimental Station, Sidney ; Experimental Sub-station, Salmon Arm.

North-West Territories—Forts Smith, Resolution and Providence Experimental Sub-stations.

Yukon Territories—Experimental Sub-station, Swede Creek, Dawson.

Field Laboratories of Plant Pathology—Charlottetown, P.E.I. ; Kentville, N.S. ; Fredericton, N.B. ; St. Anne de la Pocatière,

Quebec ; Dominion Rust Research Laboratory, Winnipeg, Manitoba ; Saskatoon, Saskatchewan ; Summerland, B.C.

Experiments now under way number about two thousand, and many of these are conducted on several of the 26 main farms, stations and sub-stations. For a complete account of these reference must be made to the " Guide to the Experimental Projects of the Dominion Experimental Farms " issued by the Department of Agriculture at Ottawa. The following gives some idea of the range of subjects covered :—

Agrostology.—Grasses and legumes, hoed crops: varieties, methods and rates of seeding, yield tests, breeding, mixtures, inoculation, cutting at different stages of maturity.

Animal Husbandry.—Beef cattle, dairy cattle, dairying, horses, sheep, swine ; hybridization, breeding, costing, feeds, housing, management, marketing, recording.

Apiculture.—Diseases, feeding, hives, honey plants, management pollination, swarm control, wintering.

Botany.—Diseases of cereals, forage crops, forest trees, fruit, potatoes.

Cereals.—Classification, cooking tests, dates and rates of seeding, selection, milling and baking, crossing, varieties.

Chemistry.—Fertilizers for field, orchard and market garden crops ; investigations on soils, feeding stuffs and fodders.

Fibre Production.—Flax, hemp.

Field Husbandry.—Rotations, cultivation, manuring, farm management, soil moisture.

Horticulture.—Canning, dehydration, greenhouse crops, ornamental gardening, pomology, vegetable gardening.

Poultry Husbandry.—Feeding, breeding, brooding, diseases, economics, egg production, housing and marketing.

Tobacco.—Cultural, curing, disease, fertilizers, seed, varieties.

Health of Animals Branch.

In the Health of Animals Branch research work is limited to the Pathological Division, and the following brief summary gives the main lines of such work at present being carried on at the Research Laboratory, Hull, P.Q., and at the Branch Research Laboratories at Lethbridge, Alta., and Agassiz, B.C.

Tuberculosis.—This is the major research problem which, in its various phases, has been under continuous study for a number of years. It includes :—

(*a*) The biological study of the tubercle bacillus in its various habitats and other variable, natural and artificial conditions ; the question of origin, type, adaptation and transmutation ; virulence, pathogenicity and attenua-

tion; chemical composition and growth requirements, cultural characters, &c., &c.

(*b*) The nature and properties of tuberculin; isolation of the separable fractions and of the active principle; hypersensitiveness to tuberculin and the specificity of the reaction.

(*c*) Studies on infection, resistance and immunity.

(*d*) Studies on avian tuberculosis and of mammalian infection with the avian type of bacillus.

(*e*) Investigation and trial of the Calmette-Guerin method of anti-tuberculosis vaccination.

These researches are carried on continuously with and in relation to the practical control and eradication of bovine tuberculosis —looking to improved methods, greater efficiency and possible new lines of attack.

The Calmette-Guerin method of anti-tuberculosis vaccination is under extensive trial and investigation. The results to date would not permit of the acceptance of some of the conclusions recently reported from several European countries. But further work and a much longer interval of time and observation are necessary before final conclusions can be reached.

Infectious or Contagious Abortion of Cattle and Bacillary White Diarrhœa of Poultry.—Research is conducted on these diseases which so seriously interfere with reproduction and cause very heavy annual losses in cattle herds and poultry flocks. In each case the adult female, suffering little or no harm herself, is the carrier of the bacillus which destroys the life of the premature born calf or of the baby-chick. It is in reality a disease of the fœtus and not of the mother. The latter being already immune, little or nothing can be expected from vaccine or serum therapy. Present research deals with the technique of different serological tests, the preparation of suitable antigens and the most specific and reliable means of detecting infection in carrier-animals and birds.

Animal Parasites and their Control.—Research to ascertain the species of parasites, particularly those infesting the digestive and the respiratory organs of animals and poultry and seriously menacing the health and life of their hosts.

Research to ascertain the action of certain drugs upon different species of parasites within the animal host.

Research on the life cycle and developmental forms of parasites outside of the animal body.

The effects of sunlight, shade, artificial heat, disinfectants and cultivation upon heavily contaminated ground and fenced enclosures.

Practical study and experiments on methods of control and prevention.

Stock Poisoning Plants.—Investigations have shown that severe losses among live stock, and especially in certain districts in the Province of British Columbia, result from eating poisonous plants. Feeding experiments and research to ascertain the danger or harmlessness of suspected forage plants and weeds is undertaken, and a study made of the symptoms and manifestations produced.

Poultry Disease Investigation.—In addition to researches on avian tuberculosis and bacillary white diarrhœa, studies on roup, chicken pox, infectious bronchitis, coccidiosis, and parasitic diseases are in progress.

Entomological Branch.

Investigations relate to the following:—

Field Crop Insects.

Grasshoppers.—Improved poison baits are now widely used in Western Canada.

Colorado Potato Beetle.—Distribution, life history and spread.

European Corn Borer.—Life history and control, breeding and colonizing of parasites.

Cutworm.—Special study of species in the prairie provinces.

Western Wheat-stem Sawfly.—It has been found that the larvæ or grubs do not cut the stems until the plants begin to lose their sap.

Hessian Fly.—It is possible to indicate approximate fly-free dates for the sowing of fall wheat.

White Grubs.—Species, life histories and habits, cultural methods of control.

Alfalfa Insects.

Root Maggots.—Corrosive sublimate for control of cabbage root maggot; Bordeaux oil emulsion spray for onion maggot.

Wireworms.—Habits and life histories.

Cabbage Flea Beetle.—Control by nicotine dust.

Hop-Plum Aphis.—Life history.

Army Worm.

Carrot Rust Fly.

Sweet Clover Insects.—Life history and control.

Tarnished Plant Bug.—Life history, habits, food supply.

Timing of Field and Truck Garden Advice.—In order properly to time the distribution of advice among the vegetable growers and gardeners, a study is in progress at Ottawa correlating the rate of development of crops with the appearance of the outstanding insects both in the Ottawa and other districts. The times of occurrence of outstanding incidents such as seeding, blooming, and

ripening of fruit are being checked throughout Canada. These are correlated as far as possible with the times of emergence, rates of development, outstanding incidents in insect life-histories such as egg-laying, damage and maturity, so that advice may be distributed from a central headquarters, timed to suit any locality in the Dominion.

Forest Insects.

These investigations relate to Lecanium Scale; Spruce Budworm, Bark Beetle, the Western Cedar Borer, Western Spruce Aphis, Larch Sawfly, European Beech Coccus, Borers in Windfalls and Logs, Spruce Chermes, Brown-tail Moth, European Pine Shoot Moth, Satin Moth and Gypsy Moth.

Fruit Insects.

Pear Psylla.—Spraying with cheap lubricating oil emulsion recommended.

Blister Mite.—Life histories, distribution, effect of injury on different varieties of fruit.

Oblique-banded Leaf-roller.—Life history.

Apple Maggot.—Life history and control.

Case Bearer of the Apple.—Control.

Apple and Plum Curculios.—Control.

Round-headed Apple Tree Borer.—Bionomics and control. Value of calcium cyanide.

Strawberry Root Weevil.—Poison bait control.

Budmoth of the Apple.—Life history, habits, control.

Codling Moth.—Parasites liberated.

Oriental Peach Moth.—Life history, habits, control, parasites.

Miscellaneous.

Insecticide Investigations.—During recent years important progress has been made in the development of new and cheaper poisons for insect control. This insecticide work is conducted particularly at Annapolis Royal, N.S. Special investigations have been made on the value of ground derris root from an insecticide standpoint, and also of other materials which might possibly take the place of arsenical mixtures in orchard and other work. Progress has also been made in connection with certain nicotine strays. The adoption of special localized spray schedules prepared by the insecticide entomologists has resulted in greatly improved crops and decidedly better market prices.

Other miscellaneous investigations have related to the European earwig, mosquitos, insects attacking stored grain, livestock insects, household insects, greenhouse insects and apple sucker.

National Collection of Insects.—The Canadian National Collection of Insects is now recognized as one of the most extensive and valuable collections in America. Important taxonomic studies based on material contained in the collection have been made. As a result of these studies, numbers of species new to science have been described and the types deposited in the National Collection.

Shipments of Parasites and Predaceous Insects to New Zealand.—At the request of the New Zealand Government collections of living chrysopid flies were made in the autumn of 1925 in British Columbia and despatched to New Zealand in the hope that the species would establish itself and prey upon destructive forms of plant lice. With few exceptions the specimens arrived in New Zealand in excellent condition. Reports received in 1926 indicated that the females had oviposited, and it is therefore hoped that this predator will survive and increase in its new environs.

Insect Pest Review.—The "Canadian Insect Pest Review," a manuscript publication, has been issued by the branch each month during the year. The object of the survey is to bring together all authentic records of the occurrence of insect pests in Canada, so that accurate information on their distribution and economic importance may be at all times readily available.

Dairy and Cold Storage Branch.

The following projects have been completed and published :—

1. An investigation of the merits of the Hoyberg test for determining the amount of fat in milk and cream. This new method was introduced into Canada in 1924 from Denmark. Results show the test to be unreliable.

2. The Cause and Prevention of Mould in Canadian Pasteurized Butter.

3. An Aerobic Spore Bearing Capsulated Bacillus.

4. The Mould, Yeast and Bacterial Content of Some New Zealand Butters.

5. Preliminary Studies of Commercial Rennets.

6. Laboratory Control in Butter Manufacture.

7. The Composition of Canadian Cheddar Cheese and Process Cheese.

8. "Surface Taint" Butter.

9. A Modified Score Card for Exhibition Butter.

The following projects are under investigation :—

1. Further studies into the causes of a flavour defect in pasteurized butter known to the trade as "surface taint."

2. Purification of creamery water supplies.

3. Factors responsible for undesirable cheese flavours.

4. A bacteriological survey of cheese factory water supplies and starters.

5. The significance of yeasts in cheddar cheese.

6. Cleaning and sterilizing cheese factory equipment.

7. Bacteriological Standards for Pasteurized Butter. (In conjunction with the American Dairy Science Association.)

8. Relation of composition of cheddar cheese to grading.

Universities and Colleges.

Research work is also carried out at several Universities and Colleges. The following is a brief summary.

Ontario Agricultural College.

Horticulture.—Cross breeding for superior strains of tomatoes and strawberries ; investigations of the factors influencing colour in apples.

Poultry.—Brooding and chick nutrition ; breeding for increased egg production ; feeds and feeding methods ; embryonic development ; control and eradication of poultry pests ; studies in egg production costs ; research in reproduction problems.

Field Husbandry.—The influence of size of piece and number of eyes on yield and percentage of marketable potatoes ; planting mature and immature potato tubers ; the influence of variety on quality and in production ; the effect of the use of different crops in mixtures ; the influence of continuous and discontinuous seed selection of various crops on yield and quality ; study of the degree of self-fertility in grasses ; the study of stooling of plants of cereals

Agricultural Economics.—Survey of farm incomes ; farm costs of individual enterprises thereon ; research in agricultural marketing ; studies of the possible and feasible substitutes for corn in the region of Ontario devastated by the European Corn Borer.

Entomology.—Research work in connection with various insect pests.

Chemistry.—Soil survey work ; the use of fertilizers · a study of the vitamin content of milk, dairy products and butter.

Apiculture.—The causes of fermentation of honey ; causes of variation in the crystallization of honey.

Manitoba Agricultural College.

Investigations are carried out on soils, crop management, forage crop breeding, cereal breeding, horticulture, plant pathology and entomology, animal husbandry and dairying, (including pigs, sheep, dairy cattle, beef cattle, horses, poultry and bacteriology), animal pathology and agricultural engineering.

University of Saskatchewan.

The investigations here relate to soils, including soil type areas and soil fertility problems; crop improvement, including breeding, with special reference to rust resistance in wheat, rye and barley; varieties of roots, grasses, &c., and the improvement of these crops by breeding and selection; hybridisation and selection for early maturity, hardiness and quality in fruit; animal husbandry and breeding, with special reference to wool problems, dairy cattle management, &c.; diseases of livestock; economics, including farm management, marketing and social life on farms; building construction and farm implement problems.

University of Alberta.

Investigations relate to soil fertility, bacteriology and soil survey; breeding of cereal and forage crops, milling and baking quality of wheat, chemical aspects of disease resistance; physiology of parasitism; animal husbandry, including both feeding and breeding.

University of British Columbia.

Investigations relate to breeding and selection work in cereals and forage crops; horticulture; genetics in relation to poultry breeding and effect of ventilation, temperature and humidity on storage of eggs; dairy bacteriology, effect of bacterial flora in milk and cream on butter and cheese; costing in horticulture, poultry keeping and dairying.

MacDonald Agricultural College, Quebec.

Investigations relate to soil acidity, soil bacteriology, soil physics; agronomy; fertilizers; breeding and improvement of fruit and vegetables; insect biology, fruit insects, entomology; protozoology; swine and poultry parasites; potato diseases; virus diseases; bacterial diseases; smut organisms; animal husbandry, including dairy cattle and swine production, breeding and nutrition of poultry, and ventilation of poultry houses; diseases of poultry; economics of poultry marketing; mole drainage; tractors.

AUSTRALIA.

1. General Survey of Conditions.

The area of Australia is 2,974,581 square miles, or, in other words, slightly over 1,900 million acres. The population is about 6,000,000, or an average of two people per square mile. This population, however, is far from being uniformly distributed, as there are two great regions which are very sparsely occupied. These are the large central area with a rainfall of less than 10 inches, and the

whole of the tropical country except the eastern portions of Queensland. More than half the total population of Australia is situated in little more than 10 per cent. of the total area. The chief reason for this unequal distribution is due to climatic conditions. Briefly, the low rainfall and high temperatures over large areas of the country are not conducive to its closer settlement.

The areas of densest population are along the southern and eastern boundaries, where the rainfall and other conditions are much more conducive to settlement than in the interior. The main industries are agricultural, manufacturing, pastoral, mining, forestry and fisheries. For the five-year period that closed at the end of 1925 the average annual values of the production of these industries were as follows: Agricultural £139,000,000 (of which £45,000,000 was due to dairying), manufacturing £122,000,000, pastoral £94,000,000, mining £22,000,000, forestry and fisheries £12,000,000. The importance of the agricultural and pastoral industries to Australia is therefore obvious.

The area under crop in Australia is steadily increasing at an average rate of about 300,000 acres per year, and in 1924–25 had reached a total of 17,278,191 acres. Of this amount over 60 per cent. is used for the cultivation of wheat, about 17 per cent. for hay, and the remainder for oats, green forage, maize, barley, horticulture, sugar cane, potatoes and vineyards, and in that relative order of importance.

The chances of greatly increasing the area under crop in Australia would thus seem to be closely connected with the possibilities of increasing the area under wheat. In the latter connection the chief natural factors involved are those of the soil and climatic conditions of rainfall and of temperature. At the present time practically all Australian wheat is grown in areas of from 7.5 to 15 inches of winter rainfall. There are large areas of unused country complying with these conditions, and it has been estimated that even in the light of present knowledge the wheat belt of Australia may be estimated at 260,000,000 acres, of which, after allowing for the necessity to fallow, etc., it would be possible to keep 40,000,000 acres under crop each year.

In 1924 the numbers of the most important varieties of livestock in Australia were approximately as follows: Sheep 93,000,000, cattle 13,000,000, horses 2,300,000, pigs 1,000,000. The number of livestock in Australia is subject to considerable variation, particularly during a time of drought. Nevertheless, it would appear that the number of sheep and cattle has now become practically stationary, and considerable increases beyond the present figures can hardly be expected unless an outstanding improvement in methods of husbandry takes place. Such improved methods will hardly be developed prior to the carrying out of a considerable amount of fundamental research.

The national importance of the agricultural and pastoral indus-

tries was recognised throughout Australia long before the days of Federation. Partly by reason of that fact, and partly on account of the many troubles met with, Departments of Agriculture arose in all six States. The chief functions of these Departments are research, demonstration and inspection. The demand for education has been met by the establishment of University Departments of Agriculture, Agricultural Colleges and Agricultural High Schools. The history of the State Departments has been more or less the same in all cases. Following their establishment they have grown in size and influence, and have continually endeavoured to keep abreast of the incessant demand for help in such matters as the study of animal and plant diseases, soil problems, entomological problems, trials of new crops, plant breeding, etc. As a result they have now become strong and of outstanding importance to Australian agriculture in general.

The importance of the State Departments may be judged from the following descriptions. The New South Wales Department is described at some length, as it is perhaps the most fully developed of the Australian organizations and its constitution is fairly typical of all of them. It is now spending about £700,000 per annum. Some thirteen comparatively large experimental stations, together with several smaller ones, have been established in localities having soils, climates, etc., typical of the different agricultural conditions that exist in the State. At these Stations investigations are carried out in order to determine the most suitable economic plants to grow in the various districts and the most suitable agricultural methods to adopt. Some £100,000 is annually spent on work of this nature and on similar work carried out in various agricultural colleges, etc. Concurrently with the above work, branches of the Department have been formed to deal with agricultural research in a more restricted sense. Each branch deals with particular phases of agriculture, and on the staffs are a number of graduates in agricultural science and in veterinary science. Special crops—for example, tobacco—are under the supervision of " experts." The various branches already established are as follows : the biological, the botanic gardens, the chemical, the dairy, the entomological, the fruit, the plant breeding, and the stock branch (subdivided into stock breeding, control of parasites and control of diseases). The Victorian Department is spending about £375,000 per annum, of which about £100,000 is used for commercial purposes, and of the remainder approximately equal amounts are spent on inspectorial, educational and research activities. The Department is divided into four divisions, the agricultural, the horticultural, the produce and the livestock. Various branches—for example, the science branch (biology, pathology, entomology, etc.), the field branch, and the chemical branch—have been formed. Several Experiment Stations have been established in different parts of the State. The annual expenditure of the Queensland Department is now about

£250,000 per annum. Its organization is very similar to that of other Departments, but one or two special branches—as, for example, the cotton branch—have been added to deal with various tropical problems. The sugar industry is specially helped by the quasi-independent Bureau of Sugar Experiment Stations. The establishment of a Tropical Agricultural Research Institute in Queensland is proposed. The Department of South Australia is spending about £50,000 per annum, and that of Western Australia about £120,000 per annum. Of the latter amount, however, about £50,000 is spent on business undertakings. The annual expenditure of the Tasmanian Department is about £20,000.

An important function of the State Departments is the training of agricultural research workers. All have either active cadet systems or have made arrangements with their local University to subsidise the training of students of agriculture. Chairs of Agriculture exist at the Universities of Sydney, Melbourne, Adelaide, Western Australia and Queensland.

The question of the co-ordination of Australian agricultural research from an Empire point of view really reduces to the co-ordination of the efforts of the six State Departments, and to a lesser extent of those of the semi-independent organizations such as Universities and Agricultural Colleges. The proposed activities of the Council for Scientific and Industrial Research have also to be considered.

Steps have already been taken to carry out agricultural research work on a co-ordinated plan as far as Australia herself is concerned. For instance, the Ministers of Agriculture in each of the States hold an annual Conference which is also attended by the senior officers of their Departments. Matters of common interest are discussed and effective co-operation is thus established. Some important decisions in the same connection were also made at a special Agricultural Conference convened by the Council for Scientific and Industrial Research early in 1927, and attended by the permanent heads of all State Departments of Agriculture, by senior officers of such Departments, by Professors of Agriculture in Australian Universities and by representatives of the Council. The Conference was of the opinion that in view of the number and magnitude of the problems confronting the agricultural and livestock industries of Australia, Commonwealth participation in agricultural research was desirable. It was also resolved that problems which are regional or national in range or scope, fundamental in character, and which require concentration of effort and highly specialized research for their solution were specially suited for investigation by the Commonwealth ; that the Council for Scientific and Industrial Research could render a service to the agricultural institutions of the Commonwealth by acting as a clearing-house of information on Australian research projects ; that the Council should adopt an appropriate scheme for the education and training of its own research workers ;

that it was desirable that the phases of agricultural research considered (they covered practically the whole field of agriculture) should be carried out as far as possible in existing institutions and that the Council should bring into existence a Standing Committee on Agriculture comprising the Permanent Heads of the State Departments of Agriculture and representatives of the Council, such Committee to act as an advisory and consultative body on matters relative to agricultural and livestock research undertaken by the Commonwealth.

The Standing Committee on Agriculture has already been formed and has held one meeting. Action along the other lines suggested by the Conference will be taken later.

In the sections that follow a survey has been made of Australian agricultural problems and of research work concerning them. The actual problems have been classified under broad headings.

2. The Principles Underlying the Practice of Agriculture and Livestock Husbandry.

(*a*) *Soil problems.*—The need for the study of the soil as a guide towards the progress of settlement has been realised in Australia since very early times. The early explorers all attempted to record the probable fertility of the soil in some measure or other, and their successors in closer settlement work, the surveyors of the State Lands Departments, make soil classification part of their work. The actual systems adopted, however, are necessarily very simple. The State Departments have taken the work a stage further and in several cases have attempted to correlate the natural vegetation of certain localities with the geological formations and soils of those areas. Soil analyses of typical areas have also been carried out and attempts made to overcome any deficiencies that might be present. The modification of the soil texture by the application of gypsum and lime has also been investigated and in some cases much success so obtained.

No systematic soil surveys, on plans in accordance with the more recent scientific knowledge available, have been carried out. It is debatable whether the benefits to be gained would ever warrant the expense of a scientific soil survey of the whole of Australia. But in the districts intended for close settlement, as for example the irrigation districts of the Murray Valley, considerable areas of which have recently been opened up, the matter assumes quite another aspect. In these cases soil surveys become relatively much more important and in the particular case mentioned arrangements have been made for a survey. The work will be under the control of Professor Prescott, of the Waite Institute, Adelaide University.

(*b*) *Production of farm crops.*—A considerable amount of work has been carried out in Australia in the direction of determining the best methods of producing various crops of economic value under various local conditions. Work of this nature forms a very important

part of the activities of the Experimental Stations of State Departments and of Agricultural Colleges, &c. It includes such work as the determination of the value of various soils for various crops, the response of such crops to fertilisers, the best rotation and tillage systems to adopt and other similar matters. In the early stages of the testing of any particular plant, work of this nature is confined largely to comparatively simple tests. As it progresses, however, it becomes more and more fundamental in nature and the latter stage has now been reached as regards cereals. In this connection investigations are now under way, particularly in Victoria and New South Wales, on such matters as the scientific principles underlying tillage, with a view to evolving superior methods of conservation of moisture, release of plant food, &c., fallowing methods, mulches, rate of humus exhaustion, and the fundamental causes of the increased yield due to application of superphosphates. The most important work on the newer crops is not so fundamental in nature and includes the operations of the Cotton Section of the Queensland Department. Extensive tests of the cultivation of sugar cane have also been carried out in Queensland, and tests of various cassava stocks are in progress. Tobacco tests have been carried out in all the Eastern States, and further it has recently been decided to initiate extensive investigations on a co-operative basis in an endeavour to place the present Australian tobacco industry on an economic footing. Some important and promising tests of rice-growing have recently been made in the Murrumbidgee irrigation settlements of New South Wales.

(*c*) *Introduction of new plants and animals.*—An enormous number of varieties of plants have been introduced into Australia from other countries. At the present time the main activities in this connection relate to the introduction of new varieties and stocks of plants. The Department of New South Wales is particularly active in the search for new varieties such as drought-resistant crops, summer legumes, grasses suitable for cold conditions and fodder plants for arid and swampy conditions.

(*d*) *Plant nutrition* (*including the improvement of pastures*).—Little or no fundamental work of this nature has hitherto been carried out. Fertiliser trials, however, have been made in all States and the effect of various soil textures, mineral content, &c., examined. Tests of the advantage likely to be gained from top-dressing various pastures have also been made. In New South Wales the composition of fodder plants and grasses as affected by climate has been studied and a certain amount of grass breeding, making use of introduced varieties, has been done. Some fundamental work on the improvement of pastures from the point of view of their possible deficiency in minerals has recently been initiated at the Waite Agricultural Research Institute, University of Adelaide, under the direction of Professor A. E. V. Richardson. This work comprises an investiga-

tion of the intake of mineral nutrients at varying stages of growth of typical pasture plants, indigenous grasses and fodders and the relation of the intake to transpiration and photosynthesis and to environmental conditions. The field work comprises an investigation of the grazing value of natural and seeded pastures under varying conditions of fertilization and the effect of grazing on the pasture succession.

(*e*) *Dairying.*—Herd testing schemes exist in all States. In addition some States have set up bacteriological laboratories where studies are made of such matters as the organisms causing taints in butter, methods of cream sterilization and lactic acid starters. Much of this work is carried out in New South Wales. The forthcoming prohibition of the use of boric acid in butter imported into England will have a very important effect on Australian exports. The best method of overcoming the difficulties caused is a somewhat contentious question in Australia. In some quarters opinion is in favour of the immediate establishment of a central Dairying Research Institute. The general weight of opinion, however, appears to be that, in view of the costs involved, such action would not at present be justified. Many State Departments have a poultry expert on their staffs and in New South Wales some investigations on poultry diseases have been carried out.

(*f*) *Horticulture.*—The fruit growing industry of Australia is a comparatively extensive one and a considerable amount of attention has been given to it by State Departments and by other organisations. On the cultivation side, many tests of various manures, of various soils, of methods of pruning, of grafting, of cross pollination, &c., have been made. As regards entomological and fungous diseases, problems such as fruit flies, red scale, black spot, downy mildew and powdery mildew of the vine, codling moth, woolly aphis, brown scale, thrips, Rutherglen bug, leaf blight of citrus, banana weevil, apple root borer, pear root aphis, cherry aphis, &c., have occupied much of the time of the Departmental scientific staffs. In some cases the investigations have been taken to the stage of the development of satisfactory control measures. A very large amount of work of the nature in question, however, still remains to be done.

Now that the Australian fruit industry has reached the stage where large quantities of all varieties of fruit can be grown for export, problems of cold storage and transport have assumed considerable importance, particularly in regard to apples of all the Southern States and to citrus fruits of the irrigation areas. Very little work has yet been done on the problem in Australia. In New South Wales one or two isolated tests on apples and citrus have been made, but in Victoria experiments on the storage qualities of many varieties of Victorian fruits, apples, citrus, pears, apricots, peaches, passion fruit, &c., have been made in eight small experimental chambers. Three different systems of refrigeration are available for these tests and the work is being continued. The Council for

Scientific and Industrial Research also proposes to regard this field of activity as one of its most important functions and for that reason Dr. Kidd of the British Food Investigation Board has spent the greater part of the year 1927 in Australia in order to advise on an appropriate programme of work. It is probable the transport conditions on shipboard will form an important part of that programme.

Problems related to the practice of irrigation constitute another important group of problems affecting a large and growing section of the Australian horticultural industry. A Viticultural Research Station has been established near Mildura, Victoria, and a Citrus Research Station at Griffith, New South Wales. These stations have now been taken over by the Council for Scientific and Industrial Research and work will be confined to the study of cultural methods. Little or no work on diseases will be undertaken. Investigations on salting of the soil, on the best methods of watering from the points of view of time and amount, soil problems and other matters will be undertaken by the Council, although not necessarily at the stations just mentioned.

(*g*) *Animal Nutrition.*—In certain parts of Australia and particularly in Western Australia, the pastoral industry is troubled by the existence of poisonous plants. Work on the problem has been carried out in New South Wales, chiefly in the direction of determining the nature of the poisonous principles and the botanical classifications of the various plants causing trouble. This work is to be intensified and extended eventually to include all Australian plants likely to be poisonous.

Some tests have also been carried out in New South Wales on the tolerance of sheep to sodium chloride in water and also on osteomalacia in cattle. In all States feeding experiments are carried out by the various stock branches.

A recent development is the initiation of a fundamental research on the nutrition of all Australian animals of economic importance. The work will be carried out by the Council for Scientific and Industrial Research and will be in charge of Professor Brailsford Robertson. A special laboratory will be erected at Adelaide University for the purpose.

(*h*) *Agricultural Economics.*—Practically no work on agricultural economics corresponding to that done by the authorities of the United States and of Great Britain is carried out in Australia. A small commencement, however, has been made by the Department of South Australia.

3. Production of New Varieties of Breeds of Plants and Animals.

(*a*) *Plant genetics.*—Little fundamental work is carried out in Australia on the mode of inheritance of botanical, morphological and other characters of plants and of the genetic factors involved in

disease resistance, with the exception of investigations on rust in wheat. Mr. W. L. Waterhouse, of Sydney University, is engaged on a classification of the biologic forms of rust (*Puccinia graminis*) in Australia, and the possibilities through genetic research of breeding immune strains o wheat.

(*b*) *Plant breeding.*—The systematic improvement of existing varieties of economic plants by the application of known scientific principles has been practised somewhat widely in Australia since the time of Farrer. Most of this work has been confined to the more important cereals, although in New South Wales plant breeding activities have also been extended to maize, sorghum and broom millet. The Australian work is mainly done by the State Departments, through the various Experiment Stations, and by Agricultural Colleges. Some of the investigations are aimed at the development of drought and disease resistant varieties, particularly of rust and smut resistant wheats.

(*c*) *Animal genetics.*—At the Australian Conference of Agriculture previously mentioned it was resolved that the genetic analysis of the economic characters of livestock including the meat quality and milk yield of cattle, wool quality and yield of wool and carcase of sheep, egg and meat quality and yield of poultry and the like constitute a group of research problems which are of national importance and require highly specialised research for their solution and form an appropriate field for Commonwealth investigation.

(*d*) *Animal breeding.*—Considerable progress has been made in Australia in the breeding and improvement of farm animals by the application of existing knowledge and principles. The well-known improvement of the Merino sheep is a case in point. Generally speaking the improvement of Australian cattle and sheep is left in the hands of the pastoral industry itself and little actual breeding is done by State authorities.

4. Disease and its Control.

(*a*) *Plant diseases, plant pathology and entomology.*—(i) Many investigations of the life histories of different causal organisms, of the modes of infection and of the conditions of attack have been carried out with a view to the suggesting of measures for control. Included in this work are such problems as the various fungi infecting wheat, oats, barley, lucerne, &c. ; bunt, flagsmut and rusts in wheat ; leaf scald of barley ; root rot of cereals ; blue mould of tobacco ; spotted wilt of tomatoes ; white wilt of oats ; fungous disease of citrus, apple, passion fruit and other fruits ; and entomological pests of cotton, sugar cane and other economic plants. Some of these investigations have been carried to a successful issue, *i.e.*, a satisfactory method of control can be suggested. In the case of many of them, however, the investigations have not gone much further than the determination of the causal organism.

Work of this nature constitutes a very important part of the scientific activities of the State Departments and of the Universities. Its value may be judged from the probability that fungous diseases of Australian cereals are alone responsible for a diminution in yield of at least 10 per cent., corresponding to an annual loss of £6,000,000. The Council for Scientific and Industrial Research will engage in some of this work. It has already initiated investigations on bunchy top of bananas, squirter in banana, and tomato wilt.

(ii) The application of known principles to the elimination of insect, fungous and other pests within definite regions is particularly a function of the State Departments. It includes such operations as spraying by various sprays and methods. A considerable amount of this work has already been carried out. The chemical composition of sprays has also been studied.

(*b*) *Animal diseases.*—Much investigation of the diseases that affect Australian livestock is carried out by the various Stock Branches of the State Departments of Agriculture and latterly by the Veterinary Departments of the Universities of Sydney and Melbourne. The research work of all these organisations, however, is adversely affected by the necessity for them to undertake routine duties such as those of education, inspection and quarantine. The Council for Scientific and Industrial Research has also decided to regard work on animal problems as one of its most important functions. The more important troubles that affect Australian stock are as follows: blow-fly in sheep, contagious bovine pleuro-pneumonia, tuberculosis, trypanosomatic diseases, worm nodules in cattle, contagious abortion and sterility in cows, contagious mammitis of dairy cows, paralysis in pigs, caseous lymphadenitis, parasitological diseases, foot rot and a braxy-like disease in sheep, toxaemic plethora in lambs, anteparturient paralysis in ewes, swelled head in rams, "Kimberley" horse disease, the Buffalo-fly in the Northern districts, the cattle tick and a number of other miscellaneous diseases.

NEW ZEALAND.

1. Survey of Conditions.

Until the middle eighties the agricultural future of New Zealand appeared to be along the lines of grain production on ploughable ground, and wool production on unploughable country. At that period, however, the advent of refrigeration, by widening export possibilities, made feasible the profitable production of commodities that previously could only be disposed of in quantities consumable by the small population of the country itself. It is not too much to say that the whole of the agricultural progress from the mid-eighties to the present day has been based on the ability to preserve perishable

commodities by means of refrigeration and transport them to the main consuming centres of the world. Before refrigeration became established development was taking place mainly on the non-forested country, where on naturally fertile land rotational farming was adopted ; and where topography or climate rendered the land unfit for this purpose, sheep-grazing entirely for wool production was carried out. Large areas of New Zealand were, however, covered with dense rain forests of a semi-tropical type, and to this day they might have remained in forest had not the cold storage of animal products been made commercially possible.

Refrigeration then has been the basal factor responsible for the turning of over 12 million acres of dense forest into grassland and the definite conversion of New Zealand into essentially a meat-and-milk-producing country. Wool production alone would never have paid for the breaking in of forest country unless with cheap labour, and it is from land formerly occupied by forest that a large proportion of the agricultural wealth is derived.

The climate of New Zealand being admirably adapted for the production of grassland with a long seasonal growth, and the major exportable commodities developing into those that can be produced on grass alone provided there is a sufficiency of such feed, grass-farming, rather than annual crop-farming, has been the definite feature of New Zealand development. Until quite recently, however, the dominance of grassland was largely viewed as representing only a temporary phase in agriculture, to be completely modified sooner or later by the introduction of more intensive methods of soil utilization, in which the annually sown crops, particularly those of a stock-feeding character, would steadily increase in importance. In actual practice the tendency has been in the reverse direction, and the proportion of both cereal and livestock-feeding crops to that of grassland is steadily diminishing. Again, the factor of manurial topdressing of pastures, now increasing enormously, is definitely swinging the pendulum of agricultural practice along the line of less reliance being placed on annual crops, and increased reliance being placed on methods of pasture manipulation and maintenance.

The basic feature of New Zealand agriculture being the production of animal products almost entirely from grassland, it must be apparent that the labour employed per acre is small. The efficiency of the individual unit of labour is extremely high. Every effort is made so that the labour on grass farms is owner labour rather than hired labour, and the majority of holdings employ no permanent hired labour at all.

Grassland and livestock being the two essential factors in New Zealand agriculture, it is not to be wondered at that consideration of the management of these two factors and the correlation of livestock management with the seasonal growth of grassland play by far the largest part in the thought, training, and development of the grassland farmer. Any practice tending to enable

him to carry and look after an increasing number of stock is readily adopted. If any such practice, however, means the employment, and permanent employment, of additional labour, it is viewed with disfavour. In a country where no stall-feeding of animals is required, the farmer has naturally adopted the principle that the higher the percentage of female stock carried, be they sheep or cattle, the greater will be the feed requirement on a farm during the spring, summer, and early autumn. In other words, by increasing the percentage of female stock on a farm, the winter feed requirement can be kept down to the lowest possible point, and without outside purchase can be made to increase coincident with the maximum period of grassland development. Indeed, the exploitation of livestock maternity is the guiding principle in livestock management in New Zealand.

With this slight introduction the guiding principles governing New Zealand as a large meat, wool, butter and cheese-producing country can now be enumerated.

(1) Grassland dominance is essential—exemplified by the fact that over 95 per cent. of the improved land is in grass.

(2) Annually sown crops should be reduced to a minimum—exemplified by the fact that in the North Island only one acre of supplementary crop is grown for every 150 stock units.

(3) The unit of permanent labour should deal with as large a number of stock as possible. This is exemplified by the fact that one individual can deal with from 25—40 cows or 400—600 sheep and their offspring, employing only casual labour from time to time.

(4) In order to make the best use of grass the summer-feed requirement of a farm must be larger than the winter-feed requirement, exemplified by the exploitation of female stock. Of the 3 million cattle nearly half are dairy cows, and over 60 per cent. of the sheep are breeding ewes.

Whether these principles are sound is a matter of opinion; the most thorough and careful economic research is required into all phases of farm management as they exist in New Zealand. This is a branch of research that did not receive attention in the past, but the paramount importance of farm economic studies has now been recognised by the Government and special attention is being paid to this phase of research.

The great bulk of agricultural research work has been undertaken by the Department of Agriculture, whose functions are viewed as being for the benefit of agricultural production, in safeguarding the individual farmer against practices that may be disadvantageous to himself and the industry in general, and in encouraging the development of practices that by experience and research have been

shown to be sound. The functions, therefore, of the Department are of a triplicate nature and comprehend regulatory, instruction, and research services. From the inception of the Department the effort has been made to blend, rather than separate, these services, and for that reason a very great deal of research and instruction has been incorporated into the ordinary administration. The absence of any University or Agricultural College direction in the actual development of farm enterprise has made the Government itself the leader and guide of agricultural progress. This has become inevitable, due to a series of circumstances. In the first place almost the whole of the annual wealth of the country is derived from the exploitation of agricultural commodities, and the success of this trade depends very largely on the improvement in standard and quality of these commodities. The protection of quality in regard to exports being a national matter, this function has naturally also become the concern of the Government, particularly so with those industries—dairying, meat-production, fruit-production and certain minor industries—that have been particularly fostered. In addition to the safeguarding of quality in export goods and all that means in the actual production of the articles concerned, the New Zealand Government, in common with many of the Imperial colonies, has had to direct the greater part of its financial policy in the closest co-ordination with the needs of agricultural development, and this of itself has further forced the Government to take the lead in directing the agricultural policy of the individual. Two other features in rural development in New Zealand have tended to throw agricultural leadership on to the shoulders of the Government—these have been the national expenditure necessary to make the Crown lands available for settlement, and the general policy of encouraging small, rather than large, holdings. The latter feature brought with it the necessity of adequate finance at a reasonable rate, and in consequence the Government itself has had to become an extremely large mortgage holder through its Advances to Settlers Department. All these features have rendered it necessary for the Government to adopt a controlling influence, sometimes by regulation, at other times by advice, over the actual development of agricultural progress and practice.

So far as agricultural research is concerned, the Government has, up to the present time, taken the view that the raising of the standard of practice to the level of the better farmer and the promulgation of those methods in buying, growing, and selling, which experience has shown to be sound, and the adoption of overseas practices clearly adaptable to the special conditions of the country, represent avenues for the advancement of agricultural progress that are of more immediate value than their substitution by long-time-sustained research, the results from which cannot be rapidly embodied in farming practice, particularly during the earlier development of virgin soils into farming and grazing lands.

Nevertheless the value of research into problems that are definitely restricting development taking place along certain directions has been fully realised, and the establishment in the past, under the control of the Department of Agriculture, of chemical, veterinary, and biological laboratories, together with experimental farms and field experimental areas under various soil and climatic conditions, indicates the importance placed on research.

A further important step has just been made in the establishment of a new Department of State, known as the Department of Scientific and Industrial Research. This Department, in co-operation with the Department of Agriculture, is devoting much of its attention to Agricultural Research.

2. Organisations Responsible for Research.

The following organisations and establishments are mainly responsible for the research work in connection with agriculture in New Zealand at the present time.

1. *The Department of Agriculture,* at its laboratories as follows :—

The Veterinary Laboratory at Wallaceville, near Wellington (dealing also with dairy matters).

The Biological Laboratory at Wellington.

The Chemical Laboratory at Wellington.

In practically all research work the technical field staff of the Department co-operate closely with the laboratory workers, and this co-operation is found to be of the greatest value. A special Dairy Research Laboratory and Institute is shortly to be erected and equipped in connection with the New Zealand College of Agriculture in process of establishment at Palmerston North.

2. *The Canterbury Agricultural College,* situated at Lincoln, near Christchurch.

This institution is maintained by revenue from endowments. It is controlled by a Board of Governors, this Board including two Government nominees. The Government subsidises the College to the extent of £1,200 per annum, and an increase of this subsidy is now under discussion.

3. *The Cawthron Institute,* situated at Nelson.

Maintained entirely by revenue from a bequest by the late Mr. T. Cawthron.

4. *Dairy Laboratories at Hawera and Hamilton.*

Both these are operated by co-operative dairy factory organisations. The Hawera establishment is subsidised by the Government to the extent of £1,000 per annum.

As stated above, an important development which has lately taken place lies in the formation of the Department of Scientific and Industrial Research.

At the new Agricultural College in process of establishment at Palmerston North, in the North Island, it is intended that a considerable amount of research shall be carried out, particularly in connection with problems affecting the dairy industry. This will necessitate a readjustment of the research activities of the Department of Agriculture, and as regards dairying it is proposed that the Department shall continue to deal with current investigations arising from the work of its Instructors in the field and in dairy factories, while the College will undertake investigations of a deeper nature involving more or less prolonged research into special problems.

3. Chief Problems under Investigation.

The *main* features of the research work at present in progress in the Dominion are as follows :—

1. By the **Department of Agriculture**:—

(*a*) *Animal Diseases* :—

Contagious abortion of dairy cows.
Failure of conception in dairy cows.
Contagious mastitis of dairy cows.
Mortality among lambs in high condition apparently due to an unbalanced highly nutritive diet.
A disease of sheep apparently allied to braxy.
Lympho-adenitis in sheep (just recommencing).
Arthritis in lambs.
The intermediate host of fluke in New Zealand.

(*b*) *Dairying* :—

Investigations into the cause of—

(i) Off-flavours, defects in body, texture and colour of butter and cheese, developing at the time of manufacture.

(ii) Measures necessary for preventing these.

Investigations into causes of defects in butter and cheese developing after storage (including investigation into methods and conditions of storage).
Investigations into better methods for maintaining milking machines and milking-mechanic parts in as continuous a state of cleanliness as possible.
The efficiency and suitability of various timbers for use in butter and cheese containers.

(*c*) *Agricultural Chemistry* :—

Iron deficiency, producing the so-called "bush-sickness" in ruminant stock.
Mortality among lambs in high condition, apparently due to an unbalanced highly nutritive diet.
Other nutrition diseases of domestic stock.

Soil survey of defined areas in both North and South Islands. These areas are (*a*) the volcanic plateau of the North Island, in which the iron deficiency area is included, (*b*) the Wellington provincial district, (*c*) the mica-sill soils of the South Island.

Investigation of various types of infertile or abnormal soils.

Researches on plants poisonous to stock and on plants with definite physiological properties, *e.g.* tutu, pukatea, Pimelia (Strathmore weed), ngaio.

Investigation of the so-called " soda-flavour " in butter.

Methods for rapid determination of casein in milk.

Control of fat-content of milk in cheese manufacture.

Investigation of abnormal milk, butter and cheese, and of difficulties arising in the manufacture of dairy products.

Milling tests of New Zealand grown wheats ; and chemical investigation and baking tests of the resultant flours, including the correlation of baking quality of flour with chemical composition, and the effect of environment of wheat on quality of flour.

Biological study of invertebrate life in forest soils.

Research on the mineral content of pastures in New Zealand.

Utilisation or disposal of waste products in agriculture and dairying.

(*d*) *Animal Husbandry* :—

Wool deterioration in certain types of crossbred sheep.

The effect of concentrated foods on the milk yield of dairy cows.

(*e*) *Plant Diseases and Insect Pests* :—

Field Crops.

Annual disease survey of farm crops.

The determination of what diseases are seed borne.

(1) Laboratory technique to ascertain presence and absence of disease in seed.

(2) Laboratory treatment of infected seed and technique to determine effect of any treatment.

(3) Field trial of treatments proved effective in the laboratory in destroying disease in or on seed to ascertain whether resultant crop is wholly disease free.

(4) Elaboration of methods to secure sufficient disease free seed for all farmers' requirements.

Diseases at present investigated or under investigation :—

Dry rot of swedes, take-all of wheat.

Cereal leaf stripe and cereal root rots.

Wheat scab, cereal smuts, cereal rusts.

Powdery scab, and

Sclerotium disease of potato. Collar rot of peas and various bacterial diseases.

Control of club root in brassicas.

(*f*) *Orchard Disease :—*

Control of brown rot by dusting instead of spraying.
Host plants and varietal susceptibility to fireblight.
Refrigeration methods in connection with the storage of fruit on land and during sea transit, including the control of flesh collapse in apples.

(*g*) *Insect Disease :—*

Disease survey of farm and forest insects.
The control of pear midge with primary parasites.
Soil sterilization in the control of subterranean insects, New Zealand grass grub, wire worms, cut worms.
The control of sheep maggot flies with primary parasites.

(*h*) *Grassland Research :—*

The types and succession under different methods of management of the sown grasslands of New Zealand.
The ecological relationships of natural grasslands in New Zealand.
Technique for ascertaining the exact area occupied by any species in a grass association. A new method, the results of which are capable of being statistically examined, known as the point analysis method, has been devised.
Harvesting and storage methods for increasing the vitality of chewing fescues and other grass seeds.
Ecotype development of introduced grasses and clover in New Zealand.
Pasture establishment and maintenance, with special regard to land of second-class quality where reversion to growth of native flora is in progress.

(*i*) *Field Experiments :—*

Technique to determine the size of plot and number of replications necessary to carry out field trials accurately. The field trials consist of topdressing experiments, and annual crop variety and manurial experiments.

(*j*) *Fertilising Practice.*

(*k*) *The Conversion into Profitable Dairy Areas* of clay land hitherto regarded as infertile and useless for farming purposes.

(*l*) *Farm Economics :—*

The study of farm management and the determination of crop and animal costs based upon different types of farms as units.

2. By the **Canterbury Agricultural College.**

Cereal seed selection and plant breeding:—

Cocksfoot seed selection and plant breeding, with special reference to the comparative feeding values as regards yield of food, of Danish and New Zealand strains of seed respectively.

The comparative values of various foods for pig-rearing and fattening.

3. By the **Cawthron Institute.**

A soil survey of a portion of the Nelson province.

Methods of bringing into profitable use hitherto infertile and unproductive land in Nelson province.

Fertiliser practice on farms and orchards in Nelson province.

Better methods of dealing with fruit culture, farm and garden crop difficulties in the Nelson province.

Cold storage of apples and pears.

The parasitic control of insect pests of farm, orchard and garden crops.

Parasitic control of blackberry, ragwort and other noxious weeds (subsidised by New Zealand Government and Empire Marketing Board).

Investigations into methods of treatment for the control of disease affecting fruit and fruit trees, also hops.

4. **The Hawera and Hamilton Dairy Laboratories.**

These establishments have not hitherto undertaken any systematic fundamental research. Their work is to deal with the causes of current difficulties in the manufacture of butter, cheese, casein, etc., and the methods necessary for overcoming them.

The Hawera laboratory is, however, controlling a seasonal test of the relative merits, for cheese making, of the milk of cows belonging to the Friesian, Ayrshire, and Jersey breeds respectively.

4. The Cawthron Institute.

This is a research institute endowed by the late Thomas Cawthron, Merchant, of Nelson, who died in 1915. After payment of death duties, the endowment was of the value of £180,000. Interest bearing securities now represent about £200,000; and all land and buildings have been paid for out of interest. The staff was appointed in 1920 and the Institute opened by His Excellency, Viscount Jellicoe, in 1921.

The main object of the institute is to benefit agriculture in its widest sense by means of scientific investigation and the communication of the results to the workers on the land. No limitation of the scope of the investigations is, however, imposed by the Constitution of the Institute. The investigations have dealt mainly with problems of farming, forestry, fruitgrowing and market gardening.

The institute building is a large private house standing in three acres of ground. The rooms have been converted into laboratories, offices, a museum and a library. The grounds are used for small scale experiments on crops and for raising seedlings for the arboretum. They also contain certain insectaries for the use of the Entomologist and fungus houses for the Mycologist, and a small meteorological station. Large scale experiments are carried out on a field scale on a number of three acre plots in different parts of the district.

The staff includes chemists, agriculturists, entomologists, mycologists, a curator who is also official Photographer, and a Librarian.

Work accomplished and in progress:

(1) The Waimea Country of approximately a million acres has been carefully surveyed as regards the distribution of the various soil types and a series of soil maps has been prepared. The soils have been analysed chemically and mechanically and crop experiments have been carried out on each of them. It is now possible to tell any farmer who quotes the official number of his block, what crops he can most successfully raise and the best treatment to adopt.

(2) Very great increases have followed the application of the advices given to farmers. Half sheep land has been raised to three sheep. Yields of fodder crops have been raised 1,000 per cent. in particular instances. Barley crops have been doubled. Raspberry crops have been raised to three times the average and similar results have been obtained with tomatoes. Lucerne has been successfully established on land hitherto regarded as quite unsuitable for this legume.

(3) Already in 1924, the Cawthron Institute was able to report that the cool store experiments had enabled the largest store in the Nelson district to reduce the losses from internal breakdown from a disastrous to an almost negligible factor.

(4) The Entomological Department is largely concerned with the introduction of enemies of the insects prejudicial to crops. The most outstanding success is the case of *Aphelinus mali*, a minute wasp, the larvæ of which has within three years so far reduced the Woolly Aphis, that this insect is no longer a source of noticeable loss to the orchardist. The annual financial benefit to the orchardists of New Zealand due to this small insect is at least equal to the total income derived from the Cawthron Trust.

Other experiments are in progress on the control of earwigs, green aphis, pear slug, oak-scale and grass grub.

(5) Insect enemies are being raised for the control of gorse, blackberry, St. John's Wort, ragwort, and other noxious weeds. This investigation is being financed by the Empire Marketing Board, which has promised £2,000 per annum, and by the New Zealand Government, which will contribute £1,000 per annum, in each case for a period of 5 years.

(6) The Mycologist has collected much information with regard to black spot on apples and pears, brown rot on many classes of stone fruit, fungi attacking timber, and various diseases of tomatoes and hops. Experiments on the control of these fungi are in progress and are giving promise of success in various directions.

(7) An investigation has been carried out in the chemical laboratories on the chemical characteristics of the petroleum from different localities in New Zealand.

Practical appreciation of the work of the Institute has been shown by several benefactors.

5. The Department of Scientific and Industrial Research.

The Act under which this Department was established provides for the setting up of a Council designated the Research Council. Its functions are defined as follows :—

(1) It shall be the duty of the Council—

(*a*) To consider and report to the Minister upon the scientific aspects of all proposals made to the Department for the encouragement and organisation of scientific and industrial research :

(*b*) To submit annually to the Minister a programme of the work, with estimates of the cost thereof, for each of the scientific institutions and services under the control of the Department :

(*c*) To make recommendations as to the expenditure of money by the Department in grants for purposes of scientific research :

(*d*) To advise the Government on the scientific aspects of any proposals made by any other Department of State and referred to the Council for its consideration and recommendations.

(2) Subject to the approval of the Minister, the Council may appoint such committees as it deems necessary to investigate and report on the work of any of the scientific laboratories, services, and institutions administered by the Department. Any such committee may consist wholly or partly of persons not being members of the Council.

The Research Council hopes especially to bring together scattered

work and workers and to assist in co-ordinating some measure of scientific attack in New Zealand on large problems in any and all lines of scientific activity, especially those problems which depend for successful solution on the co-operation of several or many workers and laboratories, either within the realm of a single science or representing different realms in which various parts of a single problem may lie.

The Research Department, in addition, is charged with the administration of the Meteorological Branch, the Geological Survey, and the Dominion Laboratory.

THE UNION OF SOUTH AFRICA.

1. Statistics.

The following statistics relate to the volume of production in main lines of farming activity in the Union, as well as the export of significant commodities. These are taken from the latest authentic figures available.

Area of Union.	No. of occupied farms.	Area of occupied farms (acres).
472,347 sq. miles	90,658 Area under cultivation (acres). 11,451,644	203,847,270

Crop Production—1925

	Wheat (1,000lbs.)	Kaffir corn. (1,000lbs.)	Maize. (1,000 lbs.)	Potatoes. (1,000lbs.)	Cotton. lbs.	Tobacco. (1,000lbs.)
European	421,417	312,214	4,187,923	310,893	20,391,818	12,763
Native	6,498	175,091	671,193	—	—	959
Total	427,915	487,305	4,859,116	310,893	20,391,818	13,722

Average Yield per Acre.

1925	Wheat	3 bags (200 lbs.)
	Kaffir corn ..	2.8 ,, ,,
	Maize	3·75 ,, ,,
	Potatoes	24 bags (150 lbs.)
	Cotton	148·5 lbs.
	Tobacco	566·5 lbs.

Livestock Returns—1925

	Cattle.	Horses.	Mules.	Asses.	Pigs.
European	6,660,053	654,085	122,000	604,842	528,085
Native ..	3,078,284	160,809	2,010	125,014	272,798
Total ..	9,738,337	814,894	124,010	729,856	800,883

	Woolled Sheep.	Other Sheep.	Angora Goats.	Other Goats.	Ostriches.
European	29,038,772	3,164,243	2,019,495	3,371,628	162,732
Native ..	2,966,855	399,842	117,699	2,514,035	—
Total ..	32,005,627	3,564,085	2,137,194	5,885,663	162,732

Export of Agricultural Products, 1926

Product.	Quantity.	Value.
Wool	211,695,494 lbs.	£12,645,851
Mohair	11,140,909 ,,	741,715
Hides and skins ..	61,589,369 ,,	2,619,045
Meat (fresh or frozen) ..	35,509,833 ,,	454,523
Eggs, fresh No.	30,069,294	180,004
Maize	293,131,254 lbs.	908,541
Maizemeal	74,989,612 ,,	206,207
Kaffir corn	9,051,374 ,,	22,799
Tobacco	868,412 ,,	107,690
Cotton	8,080,399 ,,	328,086
Fruit: Fresh	2,225,148 boxes	699,745
,, Dried	7,858,955 lbs.	128,506
Wines	168,856 gallons	26,416
Sugar	35,185,521 lbs.	15,404

Very little research connected with agriculture and its attendant sciences, is carried out in the Union other than by the Department of Agriculture and to a certain degree the Universities. An exception is research in connection with sugar production, which is being carried out by the Natal Sugar Association with a certain amount of financial aid in the shape of a Government Loan.

2. The Department of Agriculture and its Divisions.

The Department of Agriculture consists of the Secretariat and six Divisions viz. : (1) Veterinary Services ; (2) Field and Animal Husbandry ; (3) Botany, Horticulture and Entomology ; (4) Chemistry ; (5) Education and Extension, comprising four schools of Agriculture (with their subsidiary experiment stations), one in each Province of the Union ; (6) Economics and Markets. In addition the Stellenbosch-Elsenburg College of Agriculture of the University of Stellenbosch falls within the scope of the Department as a unit directly under the Secretariat.

The Faculty of Agriculture of the Transvaal University College works in close co-operation with the Department. The main source from which its funds are derived is a Government grant which is administered by the Department.

In view of the functions of the Department being largely administrative and educational, in addition to investigatory, it is difficult to determine exactly what proportion of its expenditure may be regarded as being directly devoted to research and experiment, but a careful investigation of its estimates in the light of knowledge of its duties and the method of their performance, justifies the amount of such expenditure being placed at approximately £120,000 per annum, excluding cost of land and buildings and interest on capital.

This amount, a very large portion of which is devoted to salaries and travelling expenses, may be roughly divided up as follows :

Veterinary Research	£40,000
Botanical Phytopathological and Mycological Research	12,000
Entomological Research	15,000
Chemical Research	14,000
Horticultural Research	3,000
Field Experiments for Field and Animal Husbandry Problems, including Experiment Stations ..	25,000
Agricultural Schools: proportion of salaries of scientific staff	5,000
Stellenbosch-Elsenburg College, proportion of salaries of scientific staff	3,000
Economic Investigations	3,000
	120,000

In addition to the above a sum of roughly £7,000 is spent on the publication of scientific reports and bulletins.

The Division of Veterinary Services possesses very completely equipped laboratories at Onderstepoort, near Pretoria, where Veterinary Research is carried on in addition to such routine duties as the diagnosis of blood smears and the manufacture of vaccines, etc. Branch laboratories are situated at Pietermaritzburg in Natal, Vryburg and Grahamstown in the Cape Province and Ermelo in the Transvaal. The Institution at Onderstepoort is also the seat of

the Faculty of Veterinary Science of the University of South Africa, whose members are the officers of the staff of the Department's Division of Veterinary Services.

The Division of Chemistry has its main laboratories at Pretoria, but has large branch laboratories also at Johannesburg and Cape Town; the last named, however, are mainly occupied with analyses for administrative services, as the Division, in addition to functioning in regard to agriculture, also performs chemical work for all State Departments.

The Division of Botany, Horticulture, and Entomology has its laboratories for Phyto-pathological research, as well as those for Entomological research, at Pretoria. A fairly extensive station, which when complete will be fully equipped, is being established at Nelspruit, on the Delagoa Bay railway, for research and experiment on citrus problems and sub-tropical fruits generally. It also has an excellently equipped and well-staffed laboratory at Cape Town for low temperature research.

The Division of Field and Animal Husbandry has no laboratories of its own at headquarters but possesses experiment stations at which field experiments are carried out. Any laboratory investigations it may require are carried out at its request by the Scientific branch of the Department concerned.

The Division of Economics and Markets has been recently established Among its activities, which will be later referred to, is embraced the investigation of economic problems relating to production, distribution and marketing of agricultural produce.

The Division of Education and Extension fulfils an important function in regard to research and experiment through its agricultural schools, whose activities in this respect are co-ordinated and generally directed by the respective chiefs of divisions concerned.

The Stellenbosch-Elsenburg College has an important charge committed to it in that it is responsible for all research and experiment peculiar to the winter rainfall area of the western province. In addition thereto it carries out its share in regard to problems of wider scope in collaboration with the various divisions of the Department.

3. The Chief Problems under Investigation.

Soils.—The increase of organic matter in the soil is a problem of peculiarly great importance in South Africa, as the majority of its soils owing to natural conditions are fundamentally very deficient in this respect, and, owing to its great area relative to the livestock carried and to the system of farming practice hitherto followed, the ancient use of farmyard manure cannot be adopted to the extent of other and older countries, where owing to the confinement of the stock within relatively small areas supplies of farm manure are ready to hand as needed. In this connection the possibilities of synthetic farmyard manure are under enquiry.

South African soils, further, are poor in phosphoric oxide, and the supplying of this deficiency in the most effective and economical manner is another outstanding problem.

The problem of " brak " or alkali salts on irrigated lands is also one of the very first magnitude. Lack of observance of chemical and physical conditions in determining upon irrigation projects has been the cause in the past of great loss. Much attention is being devoted to this.

The fourth great problem in relation to the soil is the maintenance of fertility in cultivated lands, and hand in hand therewith problems relating to the most efficient methods and media of fertilising various crops. This will be more specifically referred to when dealing with matters of Field Husbandry.

All these key problems are forming the subject of research by the Division of Chemistry of the Department of Agriculture in collaboration with the Chemists at the Schools of Agriculture and the two Faculties of Agriculture before referred to.

A section of the division comprising seven soil chemists with a sufficient proportion of scientific and lay assistance has been set aside for the carrying out of uninterrupted work on the soil survey of the Union. For the first few years this will, for reasons of State, be entirely confined to irrigated areas in respect of which State funds are involved.

Animal Diseases.—The problems connected with the diseases of livestock have been attacked on a very much greater scale than any other. An idea of the extent of the investigations in this respect can be gained from the subjoined recapitulation of the main ines of investigational work which is being carried out by the Research side of the Division of Veterinary Services.

Only a very brief reference to the most important researches is given.

(1) Diseases caused by *Protozoa*. This is perhaps the most important group of diseases in South Africa with its sub-tropical and tropical climate.

(*a*) *Piroplasmosis* and *Anaplasmosis* of cattle and other domestic animals. Problems of transmission, immunization and drug treatment.

(*b*) *Theileriosis* in cattle. Many problems in regard to transmission and immunity are now being investigated. Relation of *Theileria parva* infection to the Theileriosis of North Africa and other countries.

(*c*) Prevention and eradication of tick-borne diseases with special reference to the destruction of ticks by means of dipping.

(*d*) *Trypanosomiasis*. Treatment and prevention. Study of the tsetse fly problem.

(2) *Bacteriological Research* along many lines :—

(*a*) The common bacterial diseases, such as anthrax, contagious abortion, paratyphoid, etc., the main object being the improvement of existing methods of immunization.

(*b*) Toxin production and methods of immunization of diseases caused by anaerobic bacteria.

(*c*) Ricksttsia disease of ruminants—so-called Heart-water. Attempts at immunization.

(3) *Virus diseases* of animals, especially " horse-sickness," " blue tongue " of sheep, infectious anæmia of horses, &c. Stress is laid on the problem of transmission and methods of prevention by means of immunization.

(4) Study of the bionomics and methods of control of mosquitos and other *biting insects* responsible for the transmission of animal diseases.

(5) *Worm infections*, especially in sheep—œsophagostomum trichostrongylus, liver fluke and others. Methods of treatment and prevention of the infection.

(6) *Poultry diseases* of South Africa with special reference to their prevention.

(7) *Pathological study* of all South African animal diseases.

(8) *Sterility* in cattle. Diagnosis, causes and treatment.

(9) *Nutrition of stock*, with special reference to mineral metabolism. Determination of minimum physiological requirements of all mineral constituents of foods for cattle, sheep and horses ; and study of the diseases induced when any one mineral constituent is made the limiting factor in nutrition.

(10) The economic importance of supplementing *mineral deficiencies* in the natural grazing of South African pastures in relation to—

(*a*) The elimination of naturally occurring diseases such as " styfsiekte," " lamsiekte " and disorders associated with malnutrition of obscure origin.

(*b*) Growth, live-weight, age of maturity, fertility, milk yield.

(*c*) Grading up of existing stock by separating those factors concerned with *breed*, and those with *nutritional* deficiencies of the natural pastures

(*d*) The carrying capacity of the ranching areas of the Union of South Africa.

(11) The Economic importance of *Plants Poisonous to Livestock*. Study of the diseases produced (e.g. krimpsiekte, gousiekte and vomeersiekte in sheep, pushing diseases in cattle, crotalism in horses) and of the active principles of the plants concerned.

(12) *Legislative Measures* for control of stock diseases, and of importation and sale of products in connection therewith.

Animal Husbandry and Dairying.—Apart from the investigation of disease, however, a fair amount of investigational work has been carried out mainly at the Schools of Agriculture, latterly under the direction of the Division of Field and Animal Husbandry, on questions concerning the breeding, feeding and management of farm livestock, while a certain amount of work has also been performed by the Faculties of Agriculture in connection with this subject.

Investigations in this direction have been carried on in regard to the best types for South African conditions of beef cattle, the cost of production thereof and the like. It must be admitted, however, that these have been on a small scale and will have to be extended and enlarged before they can furnish results which will serve as criteria for the amelioration of the industry. From an economic point of view the beef cattle industry presents the greatest difficulties of any agricultural problem in South Africa, and its solution is greatly complicated by the fact that some 45 per cent. of the cattle in the Union are native-owned. The problem is a many-sided one, commencing with the physical conditions of the country and embracing the enormous number of scrub cattle which have to be graded up, economic considerations as to the price of ground and of fencing, the incidence of disease and the consequent need for acclimatization and immunization of bulls brought to ranching areas for improvement of foundation stock, the recurrence of droughts, problems relating to feeding and finishing, transportation of live animals or—if inland slaughtering be resorted to, in itself a difficult problem—of meat. In a country of enormous distances, the transportation problem is a very difficult one indeed. A further factor—and this is the key to the whole question—is the matter of overseas markets, in view of the fact that the success attained in veterinary matters has accelerated the rate of increase of the stock in very great degree. Unless it can be clearly shown that a good and stable market exists for meat produced surplus to domestic requirements, it will be of but little avail to demonstrate methods of improvement to cattle owners.

The Department, however, feels that steps for the improvement of cattle can no longer be delayed. Funds have been provided for a ranching station on which experiments on a commercial scale will be carried out by the Division of Field and Animal Husbandry, and a definite programme of work dealing with all the sides of the problem has been laid down with the approval of the Government.

The native factor has been referred to. This is a side of the question which presents very great difficulties indeed, which can only be appreciated by one who understands the peculiarly personal affection with which the South African native, whether he be the merest barbarian or a comparatively civilized being, regards his cattle and his consequent reluctance to sell them except under the pressure of the direst necessity. As may well be understood, such a contingency only occurs at times of drought and the like, when the cattle, owing to their impoverished condition, are of little or no value.

The cattle problem is further complicated by the fact that enormous use of trek oxen is made in South Africa, not alone for transport purposes, but also for all phases of farm work in which traction is required. This in itself presents an economic problem which will have to be faced in earnest in the immediate future.

Experimental work in the feeding of pigs for bacon production has also been carried out, but also on a comparatively limited scale.

Investigations in regard to the development of wool and hair in South African sheep and goats are also proceeding at the Grootfontein School of Agriculture in collaboration with Rhodes University College at Grahamstown. Owing to various circumstances research work in connection with the wool industry has been limited, but it is hoped in the near future to extend it considerably upon a systematic basis.

A certain amount of research work in regard to dairying has been initiated in South Africa, but only to a very limited extent. A Dairying Research institute is being established in collaboration with the Transvaal University College, in whose laboratories both chemical and bacteriological investigations will be carried out.

Crops.—With regard to crops the outstanding problems are, in regard to cereals :—

(*a*) Decreasing, by means of improved farming system, the cost of production of wheat. This will be investigated at the experiment station and farm which have recently been established in the Malmesbury District under the Stellenbosch-Elsenburg College of Agriculture. Research in the breeding of wheat, with special reference to rust-resistant varieties, is being carried on by the Department.

(*b*) *Maize.*—A prominent characteristic of maize production in South Africa is the low yield. Extensive investigations on production costs, breeding, &c., have been carried on, and a station on which experiments as well as demonstration work on a commercial scale will be carried out, has been established at Kroonstad in the Orange Free State. The ravages of the maize stalk borer are a very great factor in restricting maize production.

With regard to other field crops which are or may be of importance for export purposes, and in regard to which research is in progress, the following may be cited as of primary importance :—

Cotton insects prove a great hindrance in the development of the cotton-growing industry in South Africa, and—as will be seen later—this problem is receiving attention. The assistance of the Empire Cotton Growing Corporation has been most valuable, and the work of the Corporation's Plant Breeder at the station maintained by the Department at Barberton, Transvaal, in the breeding of Jassid resistant strains, will have a great effect upon the future of the industry. Experiments in cotton culture have for some years been carried out at the Department's station at Rustenburg, Transvaal, under the Division of Field and Animal Husbandry.

Tobacco.—The problems in this connection are mainly in the suitability of types for various markets. The Department possesses two experimental stations devoted to this work, one above referred to at Rustenburg in relation to Virginian varieties, and the other attached to the College of Agriculture at Elsenburg, Cape, at which Turkish tobacco problems are dealt with.

Fibres.—The production of flax, sisal and hemp in the Union is a matter which deserves considerable attention. Certain field experiments are being undertaken, but only upon a very limited scale.

Fruit.—Very little systematic investigation of the problems of fruit growing has up to the present been undertaken. Many problems await solution. So far as citrus and subtropical fruits are concerned these will be undertaken at the experiment station, previously alluded to, which is being established at Nelspruit ; and in regard to deciduous fruit, the main work of investigation should be greatly facilitated by the recent amalgamation, as a unit of the Department, of the Faculty of Agriculture of Stellenbosch University with the Elsenburg School of Agriculture. It has been decided to place research work in horticulture on a sound and systematic basis, and as a first step to that end a comprehensive survey of the fruit-producing industry of the Union is being made.

Considerable research work, in which the entomologist, the horticulturist and the chemist are all concerned, is in hand in connection with problems relating to arsenical contamination of fresh fruit owing to spraying against insects, the sulphuring of fruit in the process of drying and dehydration problems.

Sugar.—Field research in sugar has been referred to as being conducted at an experimental station which has been established by the Natal Sugar Association This station is situated in the northern coastal area within easy reach of Durban.

Research in Œnological and Viticultural matters is being undertaken by the Stellenbosch-Elsenburg College of Agriculture in collaboration with the Government Viticulturist.

4. The Scientific Work of the Divisions of the Department of Agriculture.

Botany. — The Department has a well-equipped and well-organized botanical service, with headquarters at Pretoria and branch laboratories at Durban in Natal and Cape Town in the Cape Province. At Pretoria the Department has built up the National Herbarium and controls the same. At Durban the famous Natal Herbarium is maintained, and a well-equipped mycological laboratory has been erected for the investigation of diseases of tropical crops and fruits. At Cape Town a mycological laboratory has been established for the investigation of fruit diseases, and there also a modern low temperature research laboratory has been provided.

The main problems dealt with from headquarters are a botanical survey and a plant disease survey of the Union on which a number of memoirs have already been published.

In connection with the botanical survey, veld reserves are being established in the several vegetation areas, their object being to preserve so far as possible the original types of vegetation and to test out their pasturage value and determine their other economic possibilities. Special attention is also being paid to the indigenous pasture plants of the country with the object of improving the carrying capacity of the veld and the meat industry generally. Diseases of citrus, tobacco and cotton have also received considerable attention. With regard to citrus, a most promising and successful campaign has been conducted against a well-known citrus canker disease, and highly encouraging results obtained. Extensive investigations have also been conducted on the moulds causing waste in citrus fruits packed for export, and as a result the percentage of waste has been markedly reduced. Many other citrus diseases, such as diplodia rot, alternaria rot, black spot, scaly bark, have been studied and dealt with. In recent years fungous and bacterial diseases of tobacco have received special attention, particularly in the case of wild fire in tobacco, and planters have derived much benefit from the investigations. Diseases of cotton have also been studied, and boll rots are at present a subject of investigation.

At Durban special attention has been directed to the virus diseases of sugar cane, maize, peanuts and tomatoes.

At Cape Town the fungous diseases of stone fruits and diseases of a physiological nature have been studied. At the low temperature research laboratory the biological, physical and engineering aspects of fruit storage and transport are being investigated and much work has been done on pre-cooling stores, refrigerator rail trucks and recording instruments necessary for the ocean transport of fruit. New and reliable instruments for this purpose have been designed and made, more efficient refrigerator trucks have been built and more suitable ship's cold chambers have been tested and recommended. The result of this work has been amply reflected in decrease of wastage of fruit and in increased prices for the same.

Entomology.—South Africa possesses an Entomological Service of wide influence throughout the country, which is a great tribute to those who pioneered it. Particular attention may be drawn to the Chairs of Entomology, one in the Stellenbosch University, the other at the Transvaal University College of the University of South Africa.

Functioning within the Department of Agriculture there are three sections: (1) the Entomological Service: (2) the Plant Regulatory Service; (3) the Educational and Extension Service.

In the Entomological Service provision is made for twenty-one trained Entomologists and three lay assistants, all functioning under the direction of the Chief Entomologist. More than half of these officers are distributed at the experimental stations or special out-stations, the remainder having their headquarters at Pretoria. At three out-stations four officers are wholly employed on Cotton Insect Investigations. In Australia the Forest Entomologist is searching for parasites of the Eucalyptus Snout Beetle, and one promising parasite is already established in South Africa. The specialist in Apiculture is supplied with a well-equipped honey house and his appointment has already had a marked influence upon the Bee-keeping industry.

To the entomological service are due some of the earliest and most illuminating investigations of the ticks attacking domestic stock and the diseases they convey. It long ago attacked the gigantic locust problem with courage and success. Remarkable improvements have been made in the means of combating this pest and at the present moment intensive studies of its habits are being undertaken.

Many and extensive investigations have been undertaken and are in progress in connection with the insect pests of orchards White Ants, the Tsetse Fly and many major and minor pests have received and are receiving considerable attention.

Chemistry.—*Fruit Investigations:* Investigations to assist in determining the stage at which fruit may be considered mature and suitable for export are from time to time undertaken. The fruit thus far given attention are grapes and oranges The influence of arsenical sprays upon the composition and quality of oranges has also been enquired into to an extent.

In connection with dried fruit steps have been taken to ascertain the required conditions for the production of dried fruit of good quality with a sulphur dioxide content sufficiently low to meet the legal requirements of England and France.

It may also be mentioned that, consequent upon the action taken under the Food legislation by the several local authorities in England, samples from consignments of export fruit are chemically tested to ensure as far as possible that all fruit sent out of the country does not contain more than a minimum amount of arsenic.

Prickly Pear: As unfortunately several species of opuntia, popularly known as prickly pear and jointed cactus, have now so spread in many parts of the Union as to have become a pest, the Division of Chemistry has taken up the investigation of the best methods under South African conditions for the destruction of the pest by poison. At the moment the use of Arsenic Pentoxide is being enquired into.

Field and Animal Husbandry.—The Division of Field and Animal Husbandry, though established at the close of 1923, has only functioned in its present form since 1926. The main function of the Division is that of carrying out investigational work in connection with production affecting livestock and crops.

Under this head, the investigational work may be divided into—(*a*) Animal Husbandry, (*b*) Field Husbandry.

Animal Husbandry.—The main investigations of national importance falling under this section are:

(*a*) *Messina Ranching Station:* At this Station investigations with five beef breeds, namely, Africanders, Shorthorns, Herefords, Sussex and Aberdeen-Angus, are being carried out in order to study the relative suitability of these beef breeds for ranching purposes, the effect of crossing these with native stock and the cost of the production of beef.

(*b*) *Sheep Feeding Station, Graaff Reinet:* Owing to severe losses, due to periodical droughts, some 900 sheep are being used in experiments at this Station, fed different rations with a view to ascertaining the cheapest method of maintaining Merino and Blackhead Persian sheep using opuntia as the basic ration, at the same time ascertaining whether the opuntia or prickly pear can be economically fed in those parts where this plant abounds or can be planted.

(*c*) A number of studies dealing with the cost of beef production from the birth of the calf and also finishing work when steers are three years old are being conducted at the Cedara and Potchefstroom Schools of Agriculture by officers of this Division. At the same Institutions, the cost of milk production, the cost of raising dairy heifers and calf feeding experiments are being conducted, and also a large range of experiments on pigs for bacon production and the cost of raising pigs for bacon and as porkers.

Field Husbandry.—(*a*) *Hartebeestpoort Experiment Station.*—At this Station a range of experiments are being conducted to work out the size of holding under irrigation on which a settler can make a satisfactory living. Varying systems of farming are being employed in these investigations. Costing work on individual crops, in addition to costing on the holdings, is also being carried out.

(*b*) *Rustenburg Experiment Station.*—Practically the whole of the attention of the staff at this Station is devoted to the investigation

into the production of cotton and tobacco. The Cotton Plant Breeder has produced seed which has been distributed to growers which has given a greatly increased yield. The tobacco work is centred round the question of producing high quality tobacco particularly suitable for export for the manufacturing of cigarettes.

(*c*) *Irrigation Experiments.*—Some 500 plots are under the charge of a Senior Research Officer of this Division at the Grootfontein School of Agriculture, where work has been conducted for the past three years on the duty of water for different crops, the effect of irrigation on the soil, &c.

(*d*) *Summer cereal investigations.*—A large range of experiments dealing with summer cereal crops for the production of pedigree seed, to suit different climatic conditions, cultural operations, fertilizing, &c., are being conducted with a view to increasing the production of maize per acre, as maize is produced on a larger scale than any other crop for export purposes.

(*e*) *Other crops.*—A large range of investigations to increase the production of winter cereals, legumes, &c., are being carried out at the various experiment stations ; in all approximately 150 projects, attacking the limiting factors affecting production, are under way.

Economics and Marketing.—Systematic investigation of the economics of South African agriculture and its problems has in the past been principally conspicuous by its absence, and the lack of authoritative data has been a great handicap in the administrative handling of questions relating to farming as well as to publicists and the progressive section of the farming community.

The foundation for investigation of general questions has now been laid by the Annual Census of Agriculture, which has been in vogue now for a period sufficient to enable its returns to be of great value for investigatory purposes. The actual industry of farming itself has never previously received any investigation by properly trained officers, but this is a matter which is now receiving attention from the Division of Economics and Markets.

Its main functions may broadly be divided into the following sections :—

1. Production and Farm Management studies.
2. Crop estimating and market intelligence.
3. Marketing investigations.
4. Agricultural Co-operation.
5. Statistics.

Under (1) Production and Farm Management studies :

(*a*) Surveys have been completed of over 100 farms held under the Land Settlement Acts and a start has now been made on a systematic investigation into holdings under closer

settlement conditions: The Bon Accord scheme close to Pretoria has been concluded and the Settlements in the vicinity of Potchefstroom will be tackled next.

(*b*) Cost of Production of Dairy products investigation has now been in progress for over a year and it is expected that a preliminary report will be available in two or three months' time.

(*c*) Plans are now in course of preparation for an economic investigation into all phases of the citrus industry in South Africa.

(*d*) An investigation into the economics of the Poultry Industry will shortly be commenced and suitable plans are being prepared for this project.

(*e*) An investigation from a distributing and marketing standpoint into the beef industry has now been completed and is being prepared for publication.

(*f*) The investigation into the cost of maize production started in 1921 is being continued.

(*g*) Cost of cotton production forms the subject of an investigation now being undertaken in co-operation with the Co-operative Cotton Exchange.

Under (2) Crop Estimating and Market Intelligence: The Division publishes regularly estimates of production of the main crops of the Union by means of Reuter's Agency, Press circulars and the monthly publication of the Division "Crops and Markets." This service has amply justified itself and is generally accepted as authoritative. Market intelligence from principal centres in the Union is collected at Pretoria and particulars of the main items are distributed by telegraph to the chief newspapers of the Union. Overseas prices secured from the Union's Trade Commissioner service are disseminated by means of Press circulars and "Crops and Markets." This combined service is gradually being extended. Arrangements have now been completed for giving monthly information on agricultural conditions throughout the Union and from September, 1927, regular statements will be made regarding the sheep and wool prospects.

(3) Marketing Investigations: Officers are stationed at Cape Town and Johannesburg who are charged with the duty of keeping close touch with market conditions. An interesting study of the Hay market at Newtown has been completed. A study of beef cattle marketing on the Rand is on hand. A report on the working of the Municipal markets has been completed.

Statistics.—A statistical section has just been started with the object of grouping the agricultural statistics into a form more suitable for the purposes of the Department, and for enabling this

Division to arrive at 5 and 10 year averages of production to facilitate checks on the crop estimating system and the establishment of normal production figures.

Extension and Education.—The Division of Extension and Education is not in itself a research division, although certain of its units, viz., the four Schools of Agriculture, carry out a considerable amount of research and experiment, largely in collaboration with the Division of Field and Animal Husbandry but also in collaboration with other Divisions. The Schools are well adapted for this purpose, as each of them contains research laboratories for the various sciences connected with agriculture, and also possesses stud stock and other farm animals and extensive areas of arable land devoted to experimental work. Further, the Schools conduct experiments on the trial of various crops and rotation and fertiliser experiments in co-operation with the farmers upon farms situated in suitable localities within their respective areas.

In addition to the staff of the various Schools who are engaged upon research or experiment, arrangements are made when necessary for the purpose of any special investigation by station officers of Divisional staffs at the Schools.

Co-ordination of research or experiment throughout the various institutions of the Department is secured by the submission of a plan of the proposed work which indicates its object and scope, proposed methods and expenditure involved, together with other relevant details. This information is circulated among the various branches of the Department which are concerned in the proposed investigations or any phases thereof for their remarks or suggestions before approval is conveyed. Prior to the adoption of this system a certain amount of overlapping and duplication as well as diversity of practice in recording progress and results took place which has now been obviated. Further it is the practice to hold annual Conferences at headquarters of the specialists in various branches of agricultural science under the chairmanship of the Chief of the Division concerned. By these means the research and experimental work carried out at Schools is co-ordinated and mutual co-operation assured.

In one other very important respect the Division is very closely connected with research work in that it is charged with the duties relating to Departmental publications including scientific reports and bulletins. This is effected by its editorial staff, which is also responsible for the issue of the monthly journal " Farming in South Africa," which is the means whereby results in popular language are communicated to the farming public for practical application. It in no sense purports to be a scientific journal. The scientific publications of the Department are issued as bulletins or reports. The sum available for this purpose during the current financial year is £7,100; the whole of this however, will not be expended on strictly scientific publications, as many Departmental bulletins are issued of a more or less popular character.

A general review of agricultural research within the Union would not be complete without reference to private workers, who are, however, but few in numbers and are mainly confined to members of the staffs of the Universities and graduate students.

It will be evident that the counting factor in agricultural research in the Union is the Department of Agriculture and that it is fairly supported by the Government and Legislature in the provision of funds. These funds are necessarily restricted owing to the heavy expenditure upon executive measures for dealing with disease among stock, notably East Coast Fever in cattle and Scab among sheep. These measures are being vigorously prosecuted, encouraging results have already been obtained and auguries for the future are favourable. As progress continues it will be possible to divert on an increasing scale a considerable portion of the moneys, at present expended on executive measures, to the strengthening of the Department's resources for research and experiment. This, it may be added, is the policy which is being clearly held in view.

In conclusion it may not be out of place to state that when scientific research is mainly confined to a Department of State, such as Agriculture, whose duties may be epitomised as increasing production and endeavouring to lessen the cost thereof and assisting in devising means for the most remunerative disposal of the produce, it is obvious that research will primarily be directed to those problems whose solution will have an *immediate* economic effect, and therefore admit of practical application by the farmer without delay.

IRISH FREE STATE.

1. **Animal Diseases.**—Since its establishment in 1899, the Department of Agriculture has given much attention to Veterinary Research in connection with the various diseases of live stock common to the country. Provision for carrying on this work was made by the Department, at first, by securing the services of eminent experts in their profession to carry out special investigations. At a later date a Veterinary Hygiene Division was set up to advise on matters relating to diseases of animals and to conduct experimental work, and subsequently a Veterinary Research Laboratory was established at Thorndale, near Dublin. In addition, general research on animal diseases is conducted at the Veterinary College of Ireland. The following is a summary of the work which has been done or which is at present receiving attention :—

Special Investigations and Veterinary Hygiene Division Work.—White scour and lung disease in calves ; braxy in sheep ; tuberculosis in cattle ; warbles in cattle ; and contagious abortion in cattle.

Veterinary Research Laboratory of the Department of Lands and Agriculture.—Bovine contagious abortion; sterility in cattle; tuberculosis; parasitic gastritis in cattle; liver fluke; diseases in sheep and cattle; mastitis; blackleg; braxy; swine diseases.

Veterinary College of Ireland.—Contagious abortion of cattle; sterility in cattle and mares; diseases due to animal parasites; the pathology of louping ill in sheep; swine erysipelas; poultry diseases (coccidiosis, tuberculosis, bacillary white diarrhœa, fowl typhoid and roup); toxic action of plants; chronic haematuria in cattle.

2. **Animal Nutrition.**—The work done in animal nutrition has, in the main, consisted of series of experiments with groups of live stock (*a*) to determine the suitability and relative value of certain foods in general use, (*b*) to ascertain the most economical combination of foods in the preparation of rations; (*c*) to determine the best method of preparing certain foods for inclusion in rations, and (*d*) to compare the effects of certain rations on live stock wintered under different conditions. The experimental work was conducted on the farms attached to the Department's educational stations at Athenry, Ballyhaise and Clonakilty, and at the Albert Agricultural College, Glasnevin. In addition, confirmatory tests were, where possible, conducted under the supervision of the county instructors in agriculture at privately-owned farms throughout the country.

Investigations completed (1900–1927).—Experiments with calves have related to the suitability of separated milk as a calf food, and its value plus milk fat substitutes as against whole milk; the most economical meal mixture to serve as a cream substitute along with separated milk from four weeks onwards; the relative value of two meal mixtures of high and low protein content when fed along with separated milk from the age of six weeks onwards; the comparative feeding value of roots and of meal mixture in the winter feed of weaning calves maintained in a progressive condition. Experiments with adult fattening cattle have been undertaken to compare the efficiency of a high protein meal mixture with a low protein one; to test the economy of supplementing the pasture with a meal mixture in the case of cattle fattening on second-rate pasture; to compare the relative value of roots and meals; to compare the feeding value of ground maize with that of crushed oats; to test the effect of "quality" of the animal on the utilization of food and to determine the feeding value of potatoes.

Pig feeding experiments have related to the comparative feeding value of meals, potatoes and separated milk; the relative value of potatoes and swedes; the feeding value of raw and cooked meals; cooked and raw potatoes; barley meal and maize meal; barley; wet and dry meal feeding; different forms of maize meals; palm nut cake (or meal); fish meal as a supplement to the ordinary ration; green food; blood meal.

Silage experiments have been carried out to compare the value of old meadow hay with that of silage made from grass of similar quality ; and to determine the food value of silage prepared from a cereal-legume crop, and to find to what extent it may replace the other parts of the cattle dietary.

An investigation has been made into the comparative nutritive value of brown (" entire " grain ground) and white (endosperm only) wheaten flour. Investigational work has also been done in connection with certain problems relating to milk production both in cows and goats.

In addition, a series of experiments, to determine the effects on milk and beef production of the improvement of pasture by the application of phosphatic manures, was conducted at the Agricultural Station, Clonakilty, during the years 1914–1919 inclusive.

Investigations in progress.

(1) The determination of the comparative feeding value for pigs of whole and ground barley.

(2) The influence of certain foods on the quality of bacon.

(3) The determination of the optimum quantity of oats in the ration of a fattening pig.

(4) Comparison of the nutritive value, for fattening pigs, of potatoes of good and bad table quality.

(5) Early beef production. The determination of (*a*) the relative economy of fattening cattle at an early age and of " storing " for some time followed by later fattening, (*b*) the optimum age at which to fatten young cattle, and (*c*) the most suitable conditions under which young cattle should be fattened.

(6) The determination of the optimum quantity of protein in the ration of laying hens.

(7) The correlation of nutritive value of pastures, as implied in their stock carrying capacity, with some feature or features of the soil or herbage.

3. **Dairying.**—Dairying, in particular the manufacture of butter, has for many years been one of the most important branches of agricultural production in Ireland, and its welfare and development have occupied the fullest attention of the Government Departments, including the Commissioners of National Education up to 1899, the Department of Agriculture and Technical Instruction for Ireland from 1900 to 1922, and subsequently the Department of Lands and Agriculture.

Investigations and research on many problems connected with the industry have been conducted mainly in regard to clean milk production, the sampling and testing of milk and cream, the sampling and testing of butter and cheese, the composition of the fat in butter,

the bacteriological and mycological floras of butters, and the physical composition of butter.

Considerable attention has been given to questions relating to the technique of dairying operations in creameries and home dairies. Research in this direction in creameries throughout the country has been in the main of an industrial aspect, dealing, as it does, with the tabulation of data recorded in connection with the various operations, the examination of results, and the efficient application of the conclusions drawn to the future methods of working. Reports on much of this work have not been published, but the information ascertained and the principles evolved have been put into general practice in the creameries. The practice of home dairying has received much attention at the Department's Institutions, where instruction in dairying is given, notably at the Munster Institute, Cork. It has been essential at such institutions, in view of the purpose which they fulfil, to carry out investigations with the object of perfecting the handling of milk and cream and butter and cheese making operations. Tests are also made with dairying utensils, equipment and machinery. The knowledge gained, though not published in reports, has been diffused through the medium of pupils attending the courses provided.

The following are particulars of some of the investigations which have been carried out or are at present being conducted :—

Quick and accurate methods of testing milk, cream, &c.. at creameries ; the sampling and determination of water in butter ; a rapid method for the determination of the fat and water content of cheese ; the composition of the fat of butter ; the disposal of creamery sewage ; the volume and density of butter ; the use of pure cultures of bacteria in the ripening of cream ; the production of " sweet cream butter " ; the quality of butter made at Irish creameries ; the use of pepsin in lieu of rennet for cheese-making ; detection of milk unsuitable for condensing purposes and removal of the causes of " blowing " ; the study of the bacterial and mycological flora of butters from various creameries with a view to the adoption of standards for purity and keeping quality ; factors affecting the separation of cream from milk ; the cause of " weak body " in butter and the factors associated with firm texture ; a physical method of separating the fats in " butter fat " ; and the cause of " black spot " in butter.

4. **Plant Pathology.**—The beginning of modern plant pathology in Ireland may be said to date from 1890, when on receipt of reports of Girard's potato spraying experiments similar work was undertaken by Carroll at Glasnevin and elsewhere. Good results were secured and an extensive series of experiments and demonstrations was immediately initiated throughout the country by various public departments which has been continued to the present day. The result of this long campaign has been that the potato crop is more widely and thoroughly sprayed in Ireland than

in any other country in the world. Calculated on the basis of the amount of copper sulphate used annually approximately 350,000 acres of potatoes are sprayed each year out of a total acreage of 530,000, including early varieties, which are not normally treated.

It is not possible to state exactly what profit acrues from the general control of potato blight in Ireland, but it is estimated that the resulting increase in yield exceeds 2 tons per acre. It may be said, without exaggeration, that the nearly universal practice of spraying has made the previous periodically recurring general failures of the potato crop an impossibility.

The scientific investigation of the diseases of potatoes has been a feature of the work of the Department of Lands and Agriculture. It is not generally recognized, however, that the inception of these investigations ante-dates the foundation of the Department in 1900 ; but sound pioneer work was carried out at Glasnevin in the nineties of the last century by Carroll, McWeeney and Wright which demonstrated, *inter alia*, the true course of events in the infection of potato foliage with blight, and the subsequent infection of the tubers from the leaves, at a time when erroneous notions were current in influential circles elsewhere. The fact has also been completely forgotten that McWeeney, as early as 1897, published a full and accurate account of stalk disease and of the fungus which causes it, as well as work on diseases of other crops. The most productive period, however, began in 1909, when a special station for the investigation of potato diseases was opened at Clifden in County Galway, under the direction of Dr. Pethybridge. Thenceforward for a period of ten years reports were published annually which dealt with all the locally important potato diseases. Some of the diseases dealt with were till then unrecognized, knowledge concerning others was confused, while the course of others was imperfectly known. Everything that was touched on in these reports was made clear and precise, and they have now passed into the accepted literature on plant diseases, and constitute the most valuable single addition to the world's knowledge of potato diseases.

Some of the diseases dealt with are :—*Phytophthora infestans* (the cause of potato blight) ; black-leg (*Bacillus melanogenes*) ; pink rot, a previously undescribed disease of considerable importance caused by an organism hitherto unknown, (*Phytophthora erythroseptica*) ; stalk disease caused by *Sclerotinia sclerotiorum ;* Botrytis disease ; Verticillium wilt ; " yellowing " due to unfavourable soil conditions ; corky or powdery scab (*Spongospora subterranea*) ; common scab ; Rhizoctonia disease, or black speck scab ; silver scurf (*Spondylocladium atrovirens*) ; " Sprain " (non-parasitic) ; dry rot (*Fusarium coeruleum*) ; and pit rot, due to unsuitable storage conditions.

A new phase of potato disease investigation began in 1920 when the Clifden Station was given up and new summer quarters were established at the Albert College, Glasnevin. The results of this work to date have been published in a series of special reports.

In part, some of the well-known diseases, such as blight, were given renewed study, and additions to knowledge were made concerning the biology of the blight fungus in the soil, the mode of its attack on the tubers, its behaviour in pitted or stored potatoes, its persistence in the soil (not, however, over the winter), the production of resting-spores in nature, and a demonstration of the initiation of foliage infection from diseased shoots derived from blighted tubers.

Principal attention, however, was devoted to the virus diseases, and good progress is now being made in this difficult field. The production of proved healthy stocks of varieties of economic (or scientific) importance has been undertaken, and these are now being inoculated with " pure cultures " of the various diseases, with a view to describing the true symptoms of these diseases on each variety.

While principal attention has been devoted to the pathology of the potato crop, as its importance demanded, valuable work has been done in other directions, as conditions required. First mention must be made of the series of three reports on flax diseases issued in connection with the Field Laboratory, Coleraine, County Londonderry (now no longer existing). These deal fully with the following diseases :—Seedling blight (*Colletotrichum linicolum*), browning and stem-break, caused by *Polyspora lini ;* rust (*Melampsora lini*) ; foot or root rots caused by Phoma and *Thielavia basicola ;* flax wilt (*Fusarium*) ; and minor diseases caused by species of *Sclerotinia and Botrytis ;* the flax flea beetle (*Longitarsus parvulus*).

In addition, papers, based on the results of original investigation, have been published concerning the following diseases of other plants :—Leaf-spots of *Arum maculatum ;* bladder-rust of Scots Pine ; celery leaf-spot ; Phytophthora foot-rot of tomato and other plants ; Keithia disease of *Thuja gigantea ; Phytophthora* rot of apples ; and Onion mildew (*Peronospora Schleideni*). Work is also in progress concerning barley seed disinfection, the control of American gooseberry mildew, the control of apple scab and other apple diseases, the Phoma rot of swedes, potato failures in the Western Islands associated with attacks of the eelworm *Heterodera Schachtii,* and the grey speck disease of oats.

5. **Plant Breeding**.— The Department's Plant Breeding Division was established in 1904. It devoted especial attention from the first years of its existence to the improvement of the barley crop, in which work it had the advantage of the active collaboration of Messrs A. Guinness, Son and Company, Ltd.

The first problem was to determine which of the numerous barley varieties grown at that time throughout the country was best suited for general cultivation, taking into consideration yielding capacity and suitability for malting and brewing purposes. An elaborate series of experiments conducted in the barley growing districts and extending over a period of six years proved conclusively that Archer was the most suitable and profitable variety, and its propagation on

a large scale and to the exclusion of all other varieties was urged by the Department.

In 1906 a quantity of seed of a strain of Archer, which was produced at the Tystofte Plant Breeding Station, was sent to Ireland. This strain gave very promising resu ts, and in tests made subsequently, in which it was compared with native Irish Archer, it proved to be superior in yield and quality of grain to the latter. In view of these results the import of Danish barley to Ireland for seed purposes grew rapidly and soon reached considerable dimensions. The Department's Plant Breeding Division, realizing that the superiority of the Danish Archer to the native Archer was probably due to the fact that the former was the produce of a pure line selection of a prolific strain, whereas the latter was not, raised a number of selections of Irish Archer, and found that the most prolific of these selections was equal in yield and quality to Danish Archer. When supplies of Pedigree Irish Archer became available to farmers, the importation of seed barley declined rapidly and became so small as to be almost negligible.

From a cross made between Archer and Spratt the variety now known as Spratt Archer 37–6 was derived. This has proved to be the most prolific variety in cultivation in Ireland, and as, moreover, the grain is well suited for malting purposes and the straw is strong, it is now grown to the practical exclusion of every other variety in the barley growing areas in the Free State.

Recently the Plant Breeding Division have obtained two other selections from Spratt Archer which appear to be more prolific than Spratt Archer 37–6.

Considerable attention has also been given to the improvement of oats, which is the most extensively grown cereal in Ireland. As many excellent varieties of this crop have been available for many years, the attention of the Plant Breeding Division has previously been directed to the production of the most prolific strains of these varieties. Such strains have been propagated and distributed to farmers under the provisions of the Department's Seed Propagation Scheme, and substantial improvement in the country's seed oats supply has been achieved in this way. Since, however, none of the strains of the commercial varieties possess straw sufficiently strong to resist lodging of the crop on very heavy soils in unfavourable seasons, the Plant Breeding Division has been endeavouring to obtain stronger strawed varieties by the use of the method of cross fertilisation. As the results of efforts in this direction Banner Tartary 9 oats has been obtained, which not only possesses stronger straw than any commercial variety, but, in addition, when grown on heavy land, is apparently superior in yielding capacity to the best commercial varieties.

The production of winter hardy varieties of oats is also engaging attention. With this end in view, prolific strains of Wexford Tawny, a very hardy old native variety, have been crossed with

Victory, Victory II, Abundance and Banner. Many forms derived from the above crossings are winter hardy and appear to be prolific, but quantitative tests with such varieties have not yet been conducted for a sufficiently long period to enable it to be definitely determined whether any of them are of economic importance.

Work on the improvement of wheat was not undertaken until quite recently. Attention is now being devoted to the production of varieties capable of producing grain of high quality for milling and baking and suitable for cultivation on soils of average fertility. Selections of prolific strains have been made from the old native varieties still being grown—though only to a limited extent—in certain areas throughout the country. In addition, numerous crossings have been made between the native pedigree strains and commercial varieties with the object of combining the good qualities of both in the new forms derived from these crossings.

The production of suitable spring wheats is also receiving attention. On the lighter soils such wheats are sometimes grown as an alternative to barley. Selections of April Red, Red Marvel and Red Fife, are being propagated. These varieties have also been successfully crossed with leading winter varieties for the purpose of obtaining prolific spring varieties. This work has, however, just been commenced, and no results are yet available.

6. **Field Experiments.**—For the furtherance of the Department's schemes of Agricultural Education inaugurated in 1901, it was arranged that field experiments should be conducted throughout the country. These experiments, which have been conducted annually since that year, have had for their main objects the determination of the most suitable and economical combinations of manures for each of the principal farm crops, the methods of cultivation best adapted to the prevailing conditions, and the suitability of different districts for different varieties of the commonly cultivated crops. The experiments were in all cases conducted at the Experimental Farms under the Department's direct control, and by the County Agricultural Instructors under the supervision of the Department on privately owned farms throughout the country.

7. **Seed Testing.**—In December, 1900, the Department of Agriculture and Technical Instruction for Ireland established in Dublin the first official Seed Testing Station in the British Isles, with the primary object of affording Irish farmers the necessary facilities for having agricultural seeds tested for purity and germination.

In the absence of technical information with regard to the details of scientific seed testing when the Station was established in 1900, it was found necessary to devote a considerable amount

of time annually to the conducting of comparative trials with germinating apparatus of various patterns and to the devising of methods of technique. As the volume of work increased, which it rapidly did, other problems presented themselves, and were, as far as possible, investigated as they arose. As a result of these investigations, methods of technique were modified or new methods were introduced to overcome the difficulties experienced.

Since the station was established, close on 100,000 samples of agricultural seeds have been tested for purity and germination, and of these, approximately 8,000 tests were of an investigational nature, the results of which have been applied in practice though not published, save perhaps in discussions at international and other seed testing conferences.

8. **Farm Costings.**—Since its establishment in 1899, the Department of Agriculture has endeavoured to encourage the keeping of simple accounts on farms for the purpose not only of enabling the farmer to apply better business methods in the management of his farm, but also of securing accurate information in regard to the economic position of agriculture throughout the country.

An investigation of farm costings was undertaken in 1919, under the auspices of the Agricultural Costings Committee.

In 1924 the Department of Lands and Agriculture undertook a more extended scheme of inquiry into farm economics in the Irish Free State, the essential factor of which was the keeping of prescribed farm accounts by a number of farmers under the supervision of the County Agricultural Instructors. Accounts have now been recorded on from eighty to ninety farms for three consecutive years and the results ascertained are at present being compiled preparatory to investigation.

In this enquiry the purpose kept in view is not the determination of detailed production costs of particular crops or agricultural products, but rather to ascertain the influence on production of such factors as area of holding, capital invested in stock and equipment, labour employed, system of farming practised, description of live-stock kept, extent of use of purchased fertilisers and foodstuffs, etc.; the measure of the influence of any particular factor on production is determined by an examination of its effects on the financial results obtained each year on the holdings, classified in groups according to type. The material obtained from the compiled records is also used to examine the distribution of the "output" from agricultural production as between the farmer and labourer and to ascertain the extent of the supplies of produce from the farm to the farm household and of the consumption on a farm of the produce raised on it

INDIA.*

1. Organisation.

Government Departments of Agriculture.—For administrative purposes British India is divided into Provinces, each with a Government of its own ; the supreme authority is exercised by the Imperial Government (or Government of India).

The Imperial Government and each of the ten Provincial Governments possesses a Department of Agriculture. (The Provincial Governments also possess Veterinary Departments.) The Provincial Governments enjoy complete autonomy as regards agricultural development within their areas. The Imperial Government concerns itself with agricultural problems of importance to the whole of India, without in any way seeking to discourage the development of research in the Provinces. Particulars of the agricultural research institutes maintained by the Imperial and Provincial Governments are given in the table on pp. 58-59. In six Provinces the research institute is attached to an agricultural college ; four Provinces possess research laboratories only. It will be seen that while there are separate Imperial research institutes for different subjects comprised within agriculture there are no separate provincial institutes for separate subjects, the whole range of subjects being dealt with at one institute. Numbers of experimental farms have, however, been established in each Province for testing varieties of crops, improved methods of cultivation, rotations, systems of irrigation, &c. ; some experimental work is also done at seed and demonstration farms. The Imperial Agricultural Research Institute, Pusa, carries out fundamental research in general agriculture, plant breeding, agricultural chemistry, mycology, entomology, and agricultural bacteriology. The Imperial Institute of Veterinary Research, Muktesar, carries out research into animal diseases and undertakes the manufacture of sera and vaccines. The Imperial Institute of Animal Husbandry and Dairying at Bangalore carries out investigations in cattle breeding, dairying, and animal nutrition. The Imperial Cane Breeding Station, Coimbatore, devotes its attention to the breeding of new seedling canes.

Semi-Government Organisations.—The Indian Central Cotton Committee at Bombay and the Institute of Plant Industry at Indore are the only two semi-Government institutions recently established which carry out agricultural and technological research. The first is a corporate body constituted under the Indian Cotton Cess Act of 1923, and is charged with the promotion of measures which will tend to further the improvement of the cotton-growing industry in India.

The Institute of Plant Industry at Indore was established in 1924

* This is a short summary of the printed publication separately circulated to the Conference.

and is financed partly by the Central Cotton Committee and partly by certain Indian States in Central India. Being situated in one of the largest homogeneous cotton tracts in the whole of India, it offers an unusual opportunity for the study of a number of problems connected with cotton cultivation and promises eventually to place knowledge of Indian cottons botanically and physiologically on a far more satisfactory basis. The Institute is managed by a Board of seven Governors ; the President is appointed by the Government of India, three Governors are appointed by the Central Cotton Committee and three by contributing States.

Private Organisations.—A few private organisations carry out research into the products with which they are concerned : these are the Indian Tea Planters' Association, the United Planters' Association of Southern India and the Indian Lac Association.

Other State Departments concerned in the improvement of agriculture.—The great irrigation works of Government are managed by a branch of the Public Works Department. There is an Imperial Department of Meteorology which maintains stations for the supply of information concerning weather conditions and prospects. A Botanical Survey of India has been in progress for many years under a Director of the Botanical Survey. The Department of Commercial Intelligence and Statistics of the Government of India compiles and publishes agricultural statistics and forecasts of crops for general information. The Geological Department of India maintains a strong body of experts both for the scientific examination of the geology of India and for the investigation of her mineral resources. Geography is represented by the important Department of the Survey of India. Forestry is the province of the Forest Department.

Agricultural Departments in Indian States.—Some of the major Indian states, as for example, Mysore, Travancore and Baroda, maintain small Agricultural Departments of their own.

Co-ordination of agricultural research.—So far as the improvement of cotton is concerned, the Indian Central Cotton Committee, which is financially and administratively self-contained, provides excellent facilities for the co-ordination of research on this important crop.

As regards co-ordination of research in other subjects, attempts have been made to provide a common meeting ground for experts of the Imperial and Provincial Agricultural Departments and other workers by establishing a Board of Agriculture in India which meets biennially, but the functions of this Board are purely advisory ; there are no funds placed at its disposal and it has no executive powers. Sectional meetings of the Board in special branches of agricultural science, such as chemistry, agricultural bacteriology, mycology, entomology, have been held occasionally ; while for the discussion of cattle-breeding problems and veterinary matters facilities have been afforded for occasional cattle conferences and

meetings of veterinary officers in India. For the co-ordination of the activities of the Imperial and Provincial Departments of Agriculture the machinery provided is, as yet, probably inadequate.

Funds.—With the exception of the Central Cotton Committee, which derives its revenues from the levy of a small cess upon the whole of the commercial output of cotton and devotes the proceeds towards the promotion of research on cotton, the expenditure of Agricultural Departments in India is met entirely from Government revenues. The Imperial Department of Agriculture is maintained from funds provided by the Central Government, while the expenditure on Provincial Departments is met by the respective local Governments.

The scientific departments maintained by private organisations get subsidies from the Government. A small cess is levied by the Government on exports of Indian teas and the proceeds of this duty are handed over to the Indian Tea Association for research and propaganda. Similarly, funds for research carried on by the Indian Lac Association are obtained by a small cess imposed by the Government of India on all exports of lac.

Private donations for the improvement of agriculture in India are very few.

The following table gives a list of research institutes and agricultural stations under Government Departments of Agriculture, semi-Government institutions and private organisations.

I. *Government Departments of Agriculture.*

1. Imperial Department of Agriculture.	(1) Agricultural Research Institute, Pusa. (2) Imperial Institute of Veterinary Research, Muktesar. (3) Imperial Institute of Animal Husbandry and Dairying, Bangalore. (4) Imperial Institute of Animal Husbandry and Dairying, Wellington. (5) Cattle Breeding Farm, Karnal. (6) Anand Creamery. (7) Sugarcane-breeding Station, Coimbatore. (8) Sugar Bureau, Pusa.
2. Department of Agriculture, Bengal.	(1) Research Institute, Dacca. (2) 23 Agricultural Stations and Farms.
3. Department of Agriculture, Bihar and Orissa.	(1) Research Institute, Sabour. (2) 20 Agricultural Stations and Farms.
4. Department of Agriculture, United Provinces.	(1) Agricultural Research Institute and College, Cawnpore. (2) 24 Agricultural Stations and Farms.

5. Department of Agriculture, Punjab.	(1) Agricultural College and Research Institute, Lyallpur. (2) 10 Agricultural Stations and Farms.
6. Department of Agriculture, North-West Frontier Province.	(1) Agricultural Station, Taru (Peshawar). (2) Agricultural Station, Taru, Haripur.
7. Department of Agriculture, Bombay.	(1) Agricultural College and Research Institute, Poona. (2) 32 Agricultural Stations and Farms.
8. Department of Agriculture, Madras.	(1) Agricultural College and Research Institute, Coimbatore. (2) 18 Agricultural Stations and Farms.
9. Department of Agriculture, Central Provinces.	(1) Agricultural College and Research Institute, Nagpur. (2) 22 Agricultural Stations and Farms.
10. Department of Agriculture, Assam.	One Research Laboratory, Shillong, and 4 Agricultural Stations and Farms.
11. Department of Agriculture, Burma.	(1) Agricultural College and Research Institute, Mandalay. (2) 13 Agricultural Stations and Farms.

II. *Semi-Government Institutions.*

Scientific Department of the Indian Central Cotton Committee, Bombay.	(1) Technological Laboratory at Bombay. (2) The Indore Institute of Plant Industry.

III. *Private Organisations.*

1. Scientific Department of Indian Tea Association.	One Research Laboratory and two Experiment stations.
2. Scientific Department of the United Planters' Association of South India.	One Laboratory and two experiment stations.
3. Institute for Lac Research (Indian Lac Association).	One Research Institute and Farm at Ranchi.
4. Agricultural Institute, Allahabad. (American Presbyterian Mission.)	(1) Allahabad Agricultural Institute.

2. Research into Various Subjects.

Agricultural Chemistry.—Agricultural colleges with laboratories, well equipped both for general teaching and research in agricultural chemistry, are maintained by the Governments of Madras, Bombay, United Provinces, Punjab, Central Provinces, and Burma. The Central Government possesses an institution for general research and post-graduate training in agricultural chemistry

at Pusa ; laboratories are maintained by the Governments of Bengal and Assam. Several of the larger Indian States have equipped laboratories, the most important of which are Mysore and Travancore. The Indian Tea Association has a large staff employed solely upon the study of tea production both from the manufacturing and agricultural aspects. In many cases the personnel have to combine both educational and research duties, a fact which militates against a large amount of the latter being undertaken.

The following investigations are in progress at the Agricultural Research Institute, Pusa, under the direction of the Imperial Agricultural Chemist : drainage records ; tobacco quality and yield; sugar beet growing ; the determination of available phosphoric acid in calcareous soils ; the movements of nitrates in soil and subsoil ; utilisation of Indian deposits of apatite ; improvement of gur from sugar-cane juice ; variations in fat content of milk of selected cows ; adulteration of butter and ghee ; the potentiometric estimation of the H–ion ; mechanical analysis and base exchange in soils.

The following are selected from the investigations in progress by Provincial Departments of Agriculture : manurial experiments (Madras) ; nitrogen recuperation of Deccan soils (Bombay) ; mechanical analysis of soils (Bengal) ; feeding value of crops and deficiency diseases (Punjab) ; drain gauges (United Provinces) ; soil surveys (Bihar and Orissa, Assam, Travancore) ; soil nitrogen (Central provinces) ; prussic acid in Burma beans (Burma).

There is a very wide field of research open in agricultural chemistry. The following are examples of problems urgently in need of investigation : the movement of water in soils ; the duty of water in regard to agricultural crops ; drainage and the rise of the water table under irrigation ; the conditions leading to the formation of saline soils and their reclamation ; the acidity and amelioration of lateritic acid soils ; and in deltaic regions the relation of the variations in the water table to crop production during dry seasons.

Information has recently accumulated which shows clearly the enormous losses due to the leaching out of nitrates which takes place in the rainy season, particularly when green manuring is practised, and investigations are urgently required into the most economical methods of employing the latter. Connected with this problem is the converse one of the annual increment of nitrogen to the soil through biochemical agencies, and investigations are necessary which have as their object the intensification of the processes involved ; associated with this is research into the most effective means of conserving soil nitrogen under tropical conditions.

In a few instances there has been a definite association of the incidence of crop disease with a deficiency of certain soil constituents and there is a wide field of investigation open in this direction for the biological chemist. Problems connected with the nutrition of particular crops require studying, and this is particularly the case in regard to rice grown under " swamp " conditions. Much work

can be done in regard to the improvement of commercial crops such as oil seeds, sugar-cane, tobacco, etc.

On the technological side work is required on the improvement of gur manufacture and its production on a larger and better controlled scale than has been attempted hitherto ; the formulation of methods which can be applied by the ryots to the better curing and marketing of tobacco ; and into the conditions governing the retting of jute and other fibre crops.

Problems connected with animal nutrition and the manufacture of dairy products and their marketing urgently require attention.

Agricultural Bacteriology.—Work on agricultural bacteriology is being carried on by the Imperial Department of Agriculture and by the Agricultural Departments of the Punjab, Central Provinces, Madras, Burma and Travancore. Bacteriological investigations are also carried on in the biochemical section of the Indian Institute of Science, Bangalore, and the Indian Tea Association. Most of the appointments of bacteriologists are recent, and the bulk of the work has hitherto been carried on at Pusa.

The work relates to the biological factors in soil fertility, nitrification and nitrogen fixation in soils, green manuring, and solubilization of phosphates. Bacterial diseases of wheat, tobacco, and potatoes and a disease of areca palm have been studied. Work has also been done on indigo manufacture, saltpetre formation, silkworm diseases, dairy bacteriology, alcoholic fermentation, antiseptics, silage, and loss of sugar by bacterial action in the mills.

Specially important problems on which work is being done at present are :—

(i) The maintenance of and fluctuations in the nitrogen supply of the soil.

(ii) Upkeep of the humus content of soil.

(iii) Supply of available phosphoric acid from indigenous phosphates.

(iv) The influence of irrigation water on soil fertility.

Entomology.—The work of the Entomological Section at Pusa comprises practically every aspect of Indian entomology except forest entomology. Investigations are carried out of insects injurious to crops and stored products and of methods for their control, and all possible information is collected regarding Indian insects, whether these are known to be of economic importance or not.

Life histories of numerous species have been fully worked out, attention being especially paid to species of economic importance such as pests of crops and fruit trees, insects injurious to stored products and manufactured goods, disease carriers of man and domesticated animals, and beneficial insects such as parasites and predators, and useful insects such as silkworm, lac and bees.

Besides the above, numerous special investigations have been

undertaken from time to time, the more important being on the Bombay locust, *agrotis ypsilon*, the Psylla disease of indigo, and the rice leaf hopper ; pests of tea and coffee ; cotton boll worm in the Punjab ; peach flies ; *Anthrenus vorax ;* San José scale ; the caterpillar pest of coconut palms.

Problems to which special attention is being given now at Pusa are : control of Monophlebus on different food plants ; sugar-cane borers ; influence of mercury on preservation from insect attack of wheat and other stored products ; preservation of wood against attack of termites ; Tabanid flies life-histories and systematics ; insect pests of domesticated animals in India ; life-histories and systematics of Indian micro-lepidoptera.

In the provinces (except in Bihar) entomological staffs are employed to investigate and deal with local pests.

Mycology.—The work at Pusa relates to mosaic, streak and deterioration of sugar-cane, wilt on rahar, sterility of rice grains due to *Fusarium ;* phytophthora ; and a disease of betel vine. Mycological work is also carried out in *Madras* (diseases of rice, sugar-cane, betel vine, coffee, tobacco, ipecacuanha, pepper and ground nuts) ; *Bombay* (cotton wilt, gummosis of citrus and grape vine mildew) ; *Central Provinces* (diseases of cotton, jowar, rice, wheat, gram, pan, sugar-cane and potato) ; *Burma* (cotton, sugar-cane, sorghum, sesamum and gram) ; *Assam* (tea diseases) ; *Punjab* (betel vine, potato, banana) ; *Travancore* (coconut palm, tapioca, banana) ; and *Mysore* (areca nut, coffee).

Agricultural Botany.—Under this head selection and hybridization work is carried out to improve varieties of crops from the point of view of yield and disease resistance, and varieties of crops are introduced from abroad. The principal crops under investigation are rice, wheat, jute, oil seeds, Indian pulses, pigeon pea, tobacco, fodder crops and fruits, and improved varieties of some of these have been distributed. The work is carried on at Pusa and in Bengal, Assam, Madras, Burma, Bihar and Orissa, Central Provinces, Bombay, Punjab, and the United Provinces. The Pusa work on wheat has a world-wide reputation.

Cotton.—Work on the improvement of the varieties grown has already achieved a large measure of success and has substantially modified the composition of the Indian cotton crop. The period since 1918 has seen a steady increase in total cotton production in India from four to six million bales and one million bales of this increase has been in long staple cotton.

In all cotton growing provinces work on cotton improvement is being carried on by modern plant-breeding methods, and practically all the important commercial varieties are now under study.

Recent developments are the two special cotton research institutes financed by the Central Cotton Committee—the Institute of Plant Industry, Indore, and the Technological Laboratory at

Bombay, and the research grants by the Committee for special problems. Increased attention is now being devoted to cotton genetics, cotton physiology and the study of the diseases and pests of the cotton plant.

The most urgent need at present is for the continuance and development of work on the improvement of the varieties grown, on cotton genetics, on the physiology of the cotton plant, on wilt disease, and on the major cotton pests.

Sugar-Cane.—Sugar-cane breeding research for the whole of India is carried on at the Imperial Sugar-Cane Breeding Station at Coimbatore in South India, conducted by the Central Government ; there are, however, stations and farms in various provinces also, and a sugar bureau of the Central Government at Pusa. Varietal, manurial and cultivation work is carried on also by private agencies. Canes bred at Coimbatore are in general cultivation.

Cattle Breeding and Dairying.—These two subjects are closely connected ; cattle are not killed, and the aim of breeding is to produce good workers in male cattle and good milkers in female cattle. India has about 100 million adult cows and she-buffaloes ; its population is largely vegetarian and requires milk and its products for growth and health.

Research work in connection with cattle breeding and dairying is now carried out by the Imperial Government at the Central Agricultural Research Institute at Pusa, at the Imperial Institute of Animal Husbandry and Dairying, Bangalore in Mysore State, at the dairy farm at Wellington in Madras, at the cattle-breeding farm at Karnal in the Punjab, and at the Government Creamery (dairy factory) at Anand in Gujarat. The facilities available may best be gauged by indicating the maximum number of cattle of all ages which can be accommodated at the various farms, viz. Pusa 400, Bangalore 250, Wellington 150, Karnal 1,000.

Breeding farms are situated at various places in the different provinces.

Investigation and experimental work in cattle breeding and dairying is also carried out by the Allahabad Agricultural Institute, controlled by an American missionary organization.

The main aim of the cattle breeding work is to convert the best of the existing mongrel types of cattle in the various districts into pure breeds having pedigree records. Good progress has already been made in establishing pure herds of most of the best types of cattle in India. Most of these herds are being developed along dual-purpose lines, *i.e.*, draught qualities in the male and milk-producing powers in the female.

The problems on which research work is in progress in the Imperial Department of Agriculture are :—The efficacy of imported sires of the best milking breeds in improving the milking qualities of Indian cattle (at Pusa and Bangalore). The effect which the weaning of the calf has on the number of calves produced and the

yield of milk given by the dam (at Pusa). The building up of a pure Indian breed of Montgomery cows as milk producers (at Pusa). The improvement of the Thar Parkar cattle of Eastern Sind by selective breeding along dual-purpose lines, *i.e.*, draught and milk (at Karnal). The improvement of the Hariana cattle of the Punjab by selective breeding along dual-purpose lines (at Karnal). The improvement of the Murra breed of buffaloes as milch animals (at Karnal). The improvement on dual-purpose lines of the Red Scindi cattle by selection (at Bangalore). The weaning and rearing of calves by hand (the universal practice in India being to allow the young calf to draw all its sustenance direct from the cow) (at Pusa, Bangalore, Karnal and Wellington). The pasteurization, cold storage and long-distance transport of city milk supplies (at Anand and Bangalore). The manufacture of hard cheese in India (at Bangalore). The manufacture, packing and transport of ghi (at Anand). The manufacture of condensed milk from buffalo's milk (at Anand). The manufacture of commercial casein in India.

There is little doubt but that the foremost problem in India for some time to come will be the preservation of the best types of cattle throughout the country and their conversion into breeds with pedigree records, but next to that the pressing problems now waiting investigation are those of dairy technique mentioned above.

Animal Nutrition.—Research in Animal Nutrition is being carried out at the Punjab Agricultural College, Lyallpur, and the Imperial Institute of Animal Husbandry and Dairying, Bangalore ; such work has only recently been commenced. In addition, work on this subject will shortly be commenced at the Madras Agricultural College, Coimbatore.

Up to the present only simple digestive experiments and observations on the consumption capacities of Indian animals have been carried out. The following may be cited :—The digestibility of some of the most common fodders ; effect of rationing on milk production ; diuresis due to fodders ; silage ; effect of environment on the quality of fodder.

Co-operation between breeding and nutrition experts is required in the better feeding of improved animals ; suitable and economic rations have to be discovered for young stock and the economics of rearing worked out ; the effect of soil, climate and manuring in the composition of crops and pastures requires to be studied as well as the rationing (especially stall feeding) of dairy cattle.

Animal Diseases.—Veterinary work in India is rendered difficult owing to economic conditions and the ethics of stock owners. The function of the Imperial Institute of Veterinary Research at Muktesar may be briefly described as follows :—

(1) Manufacture and issue of products—sera, vaccines, and agressins—for combating the more serious cattle diseases in India.

(2) Researches into the important diseases that affect livestock in India.

(3) Collection and identification of entomological and helminthological specimens of veterinary interest.

(4) Examination of morbid material, blood smears, and specimens of parasites of veterinary interest forwarded by provincial veterinary organizations and by the Military Department. This work has now developed into an item of considerable magnitude in the routine activities of the Institute.

(5) Tendering of technical advice to provincial veterinary authorities, Military and other Government Departments, and also to private organizations and individuals.

(6) Supply of trained assistants, on request, for the performance of protective inoculation on herds.

(7) Provision of post-graduate training and of short courses in Veterinary Science.

Striking advances have been made in devising satisfactory methods for the control of epizootic and enzootic disease in India. Sufficient laboratory investigation has been accomplished to bring under control the major contagious or infectious diseases (rinderpest, hæmorrhagic septicæmia, blackquarter, anthrax and probably piroplasmosis, surra and some other diseases) so far as control is ultimately practicable. The success of applied research into animal pathology has been achieved largely as a result of the field workers persuading animal owners of the efficacy of the artificial methods of control elaborated.

Rinderpest still takes a foremost place in research projects, and every endeavour is made to obtain a simple solution to the problem of its control in India.

SOUTHERN RHODESIA.

Department of Agriculture.

The Department of Agriculture, Southern Rhodesia, has within it Divisions giving special attention to each of the more important phases of the agricultural industry of the Colony. These divisions are as follows :—Agriculture (Agronomy, Crops and Horticulture) ; Agricultural Chemistry ; Entomology ; Dairying ; Poultry Husbandry ; Forestry ; Botany and Mycology ; Agricultural Engineering, and Hydrographic Engineering.

Each division deals with all aspects of the agricultural industry which fall within its particular sphere of activity, and in general the duties of the staff are divided between (*a*) research and investiga-

tion work, and (*b*) advisory and extension work amongst the farming community. While some of the divisions are in the nature of their functions engaged more particularly on investigational matters, others, such as the Dairying, Poultry Husbandry and Agricultural Engineering branches, devote the greater part of their time to instructional and advisory work.

The experiment stations of the Colony are as follows :—

(1) *The Gwebi Farm,* which is a demonstration farm worked on purely commercial lines ; attention is given to problems of arable farming from their practical side.

(2) *The Agricultural Experiment Station, Salisbury :* At this Station all initial experiments directed towards the maintenance of soil fertility and other problems connected with arable farming are undertaken. Plant introduction, variety trials with all crops suited to Rhodesian conditions, manurial and green manuring experiments, the study of pasture grasses and crop improvement by selection form important features of the work.

(3) *Bulawayo Municipal Experiment Station.*—The aims of this Station are to test and demonstrate the suitability to the drier conditions of Matabeleland of crops and methods of soil management which have proved successful on the older established experiment stations of the country.

(4) *Gwelo Municipal Experiment Station.*—A crop experiment station operated on the same lines as the Bulawayo Municipal Experiment Station.

(5) *The Tobacco Experiment Station, Salisbury.*—Devotes primary attention to the many problems affecting the rapidly expanding tobacco industry of Southern Rhodesia.

(6) *Forest Nursery, Salisbury.*—The work undertaken is almost entirely confined to raising transplants of forest trees and ornamental trees and shrubs. Advantage is also being taken of the existing eucalyptus plantations to obtain data and compile tables which will give an estimate of the rates of growth of the species suited to the country.

(7) *The M'Tao Forest Reserve.*—Afforestation work is being carried on with exotic trees, and attention is given to the conservation of and collecting information regarding the more valuable indigenous species. Experiments with regard to poisoning of undesirable species, rates of re-growth from seeds and coppice, impregnation and seasoning of timber, and many other research questions which are urgently requiring attention, will, it is hoped, shortly be undertaken.

(8) *Cotton Seed Farm, Gatooma.*—Controlled by the Cotton Specialist of the Empire Cotton Growing Corporation.

While investigating the many problems affecting the cotton industry, its primary object at present is the production and improvement of types of cotton suitable to the climatic conditions of the Colony.

(9) *The Agricultural Laboratories, Salisbury.*—In these laboratories the Agricultural Research investigations of the Divisions of Chemistry and Entomology are carried on.

Veterinary Research Department.

This Department has its headquarters at the Veterinary Research Station, an area of about one hundred acres of land situated two miles north of Salisbury.

Apart from the ordinary routine work associated with the services rendered by the Department to the public, such as the examination of pathological specimens, the preparation of horse-sickness, quarter evil, infectious abortion, and redwater and gall-sickness vaccines, research is conducted in connection with horse-sickness of equines, infectious abortion and sterility of cattle, the trypanosomiases of man and animals, sheep diseases (especially those caused by intestinal worms), deficiency diseases of stock, cutaneous myiases, and immunity in relation to local diseases of animals.

BARBADOS.

Besides the ordinary routine work of a Colonial Department of Agriculture, the Department in Barbados is engaged, or interested, in certain special lines of work which may fairly be regarded as agricultural research : these are :—

1. The raising and study of new varieties of seedling sugar-canes.

2. The study of the genetics of the sugar-cane.

3. Manurial experiments with the sugar-cane.

The basis of all manuring in Barbados is farmyard manure made up by penning and feeding live stock over trash (dry cane leaves) and gradually moulding up the pen. The most profitable combination of artificials as an addition requires to be known.

4. The control of insect pests by parasites and by other means.

Work is being done on the control of the moth (stalk) borer, *Diatraea sacchralis,* Fabr. by wasps *Ipobracon grenadensis* Ashm., and *microdus* sp).

5. A soil survey of Barbados on modern lines.

6. The biochemistry of the sugar-cane in relation to soils and manuring.

7. The composition and treatment of cane juice in relation to the manufacture of sugar.

8. New methods of utilizing molasses and megass from the sugar-cane.

9. Sea Island cotton selection work, with the view of maintaining the high standard of the Barbados strain of this variety of cotton.

10. The comparative yields and food values of different varieties of the sweet potato.

It is proposed to carry out investigations on :

(1) The comparative value of different tropical grasses as fodder ; (2) the maintenance and improvement of the standard of working oxen ; (3) the comparative value of different breeds of hogs in the tropics ; (4) the introduction of new crops, such as tobacco, auxiliary or alternative to the cultivation of sugar-cane and cotton ; (5) types of cotton suitable for Barbados as a substitute for Sea Island cotton, for which the demand is very small and is diminishing.

CEYLON.

General Survey.

The organization of research work for agriculture in Ceylon has followed the usual lines of development in Colonial administrations.

From a botanical garden established in 1810 for the purpose of trials with economic crops under the guidance of practical horticulturists, and a change of site to the existing Royal Botanic Gardens at Peradeniya in 1822, development on the scientific side has gradually been extended. The scientific directors of the Royal Botanic Gardens began investigations of the Ceylon flora, and the record of botanical research on the systematic side resulted in a complete knowledge of the flora of the island. Meanwhile, changes in the trend of botanical investigations were not without their influence in Ceylon, and definite histological, physiological and ecological investigations were made. The introduction and acclimatization of economic and ornamental plants formed an important part of the work of the Gardens, and later requirements demanded provision for the investigation of the commercial possibilities of certain crops, the study of pests and diseases and the physical and chemical properties of soils. This led eventually to the gradual development of the Department of Agriculture which, as a Government institution, endeavours to stimulate agricultural development, spread agricultural knowledge and generally improve the methods and results of agriculturists.

This Department consists of administrative and research branches at headquarters and divisional agricultural and pest control organizations. Other departments of Government deal with other subjects related to agriculture, *e.g.*, irrigation projects are investigated and constructed by the Irrigation Department, the meteorological

observatory forms part of the Survey Department, and veterinary matters are dealt with by the Veterinary Department. Separate industries have been encouraged also to provide for research for themselves, and in 1926 a Tea Research Institute was established by the tea industry. For some fourteen years a special Research Scheme, formed by the co-operation of the Ceylon Government with the Rubber Growers' Association and rubber estates in Ceylon, has been working on problems of the rubber industry.

A.—Department of Agriculture.

The Department has in recent years set itself the task of assisting the prevention of soil erosion in hilly sections, the development of a permanent system of cultivation to replace the existing shifting cultivation of jungle areas, the development of cotton and tobacco growing in definite areas, the improvement of paddy cultivation, the control of pests and diseases, in addition to specific researches by its various specialist divisions.

Mycological Division.—This division examines generally and reports upon all cases of plant disease of fungus origin of economic (and other) plants. It conducts special research work, and at the present time has in hand certain definite investigations relating to diseases of the main economic crops; the investigation of the distribution, conditions of occurrence and biology of root disease fungi in general and *Rhizoctonia bataticola* in particular, coconut root diseases, bunchy top disease of plantains, the diseases of paddy and the biology of *Diplodia*.

Of the problems in hand that of *Rhizoctonia bataticola* is perhaps the most important, for it seems to shed entirely new light on the causation of root disease in the tropics. It has given rise, in fact, to a new view which must be tested by the experience of as many regions as possible throughout the tropics.

Entomological Division.—This division is concerned mainly with the investigation of the various insect pests of the different economic crops of the island. In recent years special investigations have been made into the shot-hole borer pest of tea, tea tortrix and other pests of tea. Arrangements have been made for most of the investigations of tea pests to be handed over to the Tea Research Institute, but work on tea termites (*Calotermes sp.*)—one of the most important present-day problems of the tea industry in Ceylon—and on scale insects (*Coccus viridis* and *Saissetia hemispherica*) is being continued by this division. Special attention has been given to the insect pests of green manures and shade trees and to various pests of important vegetable and food crops. Epilachna and Aulacophora beetle pests of cucurbits, the bean fly (*Agromyza*) and pests of plantains are at present securing special attention. The control of *Opuntia dillenii* by means of *Dactylopius tomentosus* has recently been undertaken and is progressing successfully. Plans for the development of seri-

culture (the Eri silkworm) have been made, and preliminary experiments with some insecticides are being carried on.

Chemical Division.—This division has only recently been organized and the chief problems that have been, or are, in hand are as follows :—

(1) The decomposition of green and organic manures under Peradeniya conditions ; (2) nitrogen-fixation in Ceylon soils generally ; (3) the leaching of fertilizers from Ceylon soils ; (4) the mineral analyses of a large number of Ceylon's cultivated and uncultivated fodder grasses have been carried out.

Division of Economic Botany.—The work of this division is at present as follows :—(1) Selection of pure line strains of rice, their testing, and distribution to Divisional Officers. (2) Pure line selection of *Eleusine corocana* and other fine grains. (3) Pure line selection of certain vegetables, e.g. *Hibiscus esculentus, Vigna sinensis.* (4) Cultural and manurial experiments with rice : general work on rice agronomy. (5) Research on the technique of testing rice selections. (6) Classification of the Ceylon rices.

This division was started primarily to effect an improvement in the paddy industry, and has up to the present time produced a number of pure line paddies which are now in the process of testing upon 19 different stations in various parts of the island.

Division of Systematic Botany.—This division deals with identifications of Ceylon plants, and has in hand at the present time research work on certain groups, the preparation of a supplementary volume to the flora of Ceylon, and the preparation of a students' handbook of the flora.

Central Experiment Station.—This is the main experiment station of the Department, and various researches in general agriculture are being carried on. The main crops are tea, rubber, cacao, coffee, paddy, fodder grasses, green manures and cover crops, fruit. Cattle breeding is also being commenced. The experimental work comprises the measurement of actual amounts of soil erosion taking place and trial of ameliorative measures, cover crops, &c. ; manurial experiments with tea, rubber, coffee, cacao, &c. ; cover crop experiments in tea and rubber, varietal tests with coffee, coconuts, tapping experiments with rubber ; the vegetative propagation of Hevea and the correlation between various vegetation characteristics.

Plant Pests and Diseases Inspection.—This division is charged with the prevention of the importation of pests and diseases at ports of entry and with the control measures against weeds and pests and diseases of the principal economic crops. It is responsible for field investigations of different pests and diseases, and has recently been engaged upon a campaign of eradication directed against the water hyacinth.

Agricultural Divisional Organization.—The divisional agricultural officers are responsible for the control of experiment stations, testing and distribution of improved varieties of crops (especially paddy), general agricultural investigations, and the development in their respective divisions of special industries, agricultural education and co-operation. The extension and propaganda work of the Department is carried on through the divisional organization, and special investigations on paddy, cotton, tobacco and crop rotations are being conducted. The island has been divided into six divisions, but at the present only four have been organized.

Botanic Gardens.—The Botanic Gardens in Ceylon consist of the Royal Botanic Gardens, Peradeniya, established in 1822, the Botanic Gardens, Hakgala, established in 1860, and the Heneratgoda Botanic Gardens, opened in 1876. These gardens continue introductions and acclimatization of plants of botanical or economic importance. Special attention has been given recently to those trees which yield Chaulmoogra oils required for the treatment of leprosy, to further trials with improved types of Cinchona and to the vegetative propagation in the various nurseries of the Gardens of improved strains of tropical and sub-tropical fruits. It is expected that this last-mentioned work will assume much larger proportions within the next few years.

Co-operative Division.—This is charged with the development of co-operative organizations for credit and for the purchase of supplies and for the sale of produce.

B.—Rubber Research Scheme.

This scheme is managed by an Executive Committee in Ceylon, of which the Director of Agriculture is chairman, with the advice of a special committee in London. Technical committees have also been formed both in Ceylon and in London. The scheme is responsible for definite technical researches into the rubber tree and its products. Investigations into crop improvement, the physiology of the rubber tree, the chemistry of latex and of rubber, the diseases of rubber, are being made in Ceylon and into the vulcanizing, ageing and other properties of raw rubber from Ceylon by a special staff in London.

Chemist.—(1) The effect of different dilutions of latex when formic acid and sodium silicofluoride are used as coagulents; (2) experiments on the utilization of waste serum; (3) to determine the effect of the mineral content (such as iron) of factory water on the quality of rubber produced; (4) experiments with a view to improving plasticity; (5) experiments on the elimination of smoking; (6) packing of rubber (smoked sheet); (7) to determine the effect of rolling on the drying of sheet and crepe rubber and on the quality of the rubber; (8) experiments with a view to improving ageing properties of rubber when vulcanized in a rubber sulphur mixing; (9) to study the economics of factory work with a view to standard-

ization of the methods employed, machines in use, &c., also to enquire into the question of smoke houses and the smoking of rubber as carried out on estates ; (10) to study the effect of manuring of rubber, the most suitable mixture to apply, the best methods of application and the quantity to apply under the varying conditions of rainfall and soil in Ceylon. Also the effect of manuring on diseases.

Physiological Botanist.—(1) Investigation of brown bast ; (2) selection of high yielding types and testing of same in the field : vegetative propagation ; (3) study of characters of high-yielding trees and correlation of such characters ; (4) study of the contour system of planting for the prevention of soil erosion and of various cover crops ; (5) study of the change-over system of tapping ; (6) manurial experiments with rubber.

Mycologist.—(1) Further investigations of bark diseases and of the use of disinfectants on tapping cuts ; (2) further study of pod-disease and leaf fall and of the practicability under Ceylon conditions of spraying.

The programme of work in London for 1927 is as follows :—

(1) The extent and causes of variability of Ceylon plantation rubber in respect of (*a*) plasticity, (*b*) time of vulcanization and mechanical properties in different mixings, (*c*) ageing.

(2) Developments in the rubber industry of direct interest to the planter, e.g. (*a*) sprayed rubber, (*b*) Revertex.

(3) Possible differences between fine hard para and plantation rubber which may account for the preference of manufacturers for the former for the manufacture of such articles as golf ball tape, elastic thread.

(4) The effect of the non-caoutchouc constituents of latex on the ageing of the raw and vulcanized product.

(5) The use of latex serum products.

(6) The behaviour of different samples of plantation rubber when successively exposed to temperatures about 0° C. and 20° C.

Examinations will also be made of samples prepared in connection with investigations in progress in Ceylon, e.g. (*a*) the use of paranitrophenol, (*b*) spraying of trees with fungicides, (*c*) methods of smoking and drying.

C.—Tea Research Institute.

This separate organization has recently been formed by the tea industry through a cess on exports collected by Government at the Customs.

It is at present located in temporary quarters, but negotiations are now in hand for the purchase of a tea estate for experimental

work and for the location of its laboratories and factory. The Institute is managed by a Board of Management of ten members representative of the various interests connected with the tea industry in Ceylon, together with the Director of Agriculture and the Colonial Treasurer as Government representatives. The Institute has only recently been organized and its staff has only just been secured. The following initial programme of work has been agreed on :—

Biochemist.—Chemistry of the tea leaf, to test out methods of analysis and select standard methods for adoption in all subsequent work. Investigation of hydrogen ion concentration of soils in relation to yield and quality.

Soil Chemist.—Investigation of the decomposition of manures, nitrification, losses by leaching, &c., co-operative manurial experiments and experiments on soil erosion.

Mycologist.—Investigation of the Cercosporella leaf disease and its relation to acacias and other green manure plants. Investigation of the Diplodia root disease, especially as regards the curative action of lime. Investigation of diseases of tea seedlings. Hydrogen ion concentration of soils in relation to disease.

Determination of the micro-organisms present on the flush at different seasons before and after withering.

Investigation of the Ambrosia fungus of the Shot-hole Borer beetle and the determination of the relations between the fungus and the bush, with a view to a possible method of control of the beetle.

Entomologist.—Investigation of Scarlet Mite (the "Red Rust" of the Haputale District), Tea Tortrix, Nettle Grub.

D.—Meteorological Department.

This forms part of the Survey Department, and issues reports on its various meteorological investigations and researches.

E.—Veterinary Department.

This Department is charged with the investigation of diseases of animals in the Colony and with the control of any outbreaks which may occur. A considerable variety of agents has been tested for effect on the fourth stomach worm (*Mecistocirrus digitatus*) of cattle, which causes much loss. The Department also has charge of the Government Dairy at Colombo. It is conducting an investigation into the crossing of Indian Cattle (Zebus) with the European breeds ; imported Ayrshire bulls are being tried with promising results At present it is also engaged upon investigations into the nutrition of animals and the results of deficiencies of certain mineral constituents in fodder and feeding stuffs. A disease—osteoporosis—is believed to be chiefly due to mineral deficiency. It is considered that the island pastures are chiefly deficient in calcium.

CYPRUS.

The two main problems which confront the Agricultural Department of Cyprus cannot in the nature of the case be solved by research work alone. The first problem is that of the water supply. The mean rainfall in the principal agricultural centres does not exceed 12 inches annually, and is unevenly distributed over the year. There is as yet no widespread system of water-storage and of irrigation. Reafforestation of the island will help to preserve in the soil the moisture provided by the rainfall, and artesian boring will increase the supplies of water already to hand. The second main problem is presented by the conservative character of the villagers. Efforts are being made to introduce modern methods amongst them.

The chief crops in Cyprus are :—Wheat, Barley, Oats, Vetches, Broad Beans, Flax, Favetta, Lentils, Chick Peas, White Cumin, Aniseed, Cotton, Hemp, Sesame, Cow Peas, Water Melon, Maize, Ground Nuts,Tobacco, Potatoes, Citrus trees, Pomegranates, Apricots, Cherries, Apples, Peaches, Hazelnuts, Walnuts, Pears and Loquats, Olives, Carobs, Figs, Almonds, Rose, Lavender, Minth. Pyrethrum is also now grown, though to a less extent than the others.

All of the above grow well in Cyprus and their further exploitation depends chiefly upon the two conditions already noticed—water supply and the employment of modern methods of cultivation.

Research by the Agricultural Department of Cyprus is limited to a large extent by financial considerations and by the fact that the staff of the department is not sufficiently large for any one member to devote the major portion of his time to scientific research work.

Recent investigations have related to wheat, flax, and cotton ; the chief plant diseases and pests of crops in Cyprus have been determined.

FALKLAND ISLANDS.

There is no officer in Government service who is engaged in agricultural research work.

An investigation was recently made into the conditions and practice of sheep farming in the Colony by the Principal District Inspector of the New Zealand Department of Agriculture. In accordance with a recommendation made in this report the Government is establishing an experimental farm at Anson on Port Louis, East Falkland ; the primary object of the experimental farm will be to determine on a small scale the course which major operations should follow in the direction of replenishing exhausted soil and pastures : in particular the re-grassing of hard "camp" by surface sowing, and the growing of roots and other forage crops. The reclamation by drainage of water-logged valleys or wet camp is also to be undertaken.

FEDERATED MALAY STATES AND STRAITS SETTLEMENTS.

General Survey of Conditions.

The areas under the major crops are : rubber 2,250,000 acres, padi 650,000 acres, coconuts 500,000 acres, and oil palms 15,000 acres. There is a large importation of labour to deal with these crops. This labour and some portion of that of the Malays themselves is absolutely non-productive as far as food is concerned, with the result that Malaya has a very high ratio of imported to home-grown foodstuffs. The immigrant labour would not remain long at work for low wages : it is useless, therefore, to experiment with new crops or new processes which will never repay high labour costs. This fact has influenced the whole course of research work.

Scientific Organisations dealing with Agriculture.—The first body to carry out research work was the Department of Agriculture started in 1905, owing to the recognition of the need for scientific assistance to the rubber industry. About the same time or shortly after came the Malay Peninsula Agricultural Association Laboratory, the Rubber Growers' Association Laboratory, the Société Financière Laboratory and two or three private mycologists on the larger estates. The Rubber Research Institute of Malaya, which was formed in 1926, has now taken over all the work on rubber which was being carried out, including the research work recently in progress at the Department of Agriculture. There are now no private organisations at work.

Organisation of the Department of Agriculture.—The present Research staff is arranged in the following Divisions :—Chemistry, Botany, Mycology, Entomology, Soils and Plant Physiology, Agriculture. There are in addition the Field Division and an Agricultural Economist. The results of research are published in the Malayan Agricultural Journal and in special bulletins.

With the formation of the Rubber Research Institute, the Department will have much more time for research on crops other than rubber. The necessity for such research was sharply demonstrated during the last rubber slump, when there was an insistent demand for " other crops." The economic conditions of Malaya alluded to above must, however, be kept in mind.

Rubber.

Most of the research work carried out deals with rubber.

Diseases and Pests.—The earliest trouble were " Die-back " and the " White-ant " (*Coptotermes gestroi*).

It was soon found that the former was only indirectly due to the associated fungus *diplodia* and was really an indication of over-

crowding, while subsequent work on *gestroi* showed that they could be controlled by removing decaying timber. Other diseases studied have been a root disease caused by the fungus *Fomes lignosus*; a collar disease due to *Ustulina maxima*; "wet-rot" (*Fomes pseudo-ferreus*); diseases of the tapping cut such as "black-stripe" (*Phytophthora*), "mouldy-rot" (*Sphaeronema fimbriatum*) and "brown bast" (a physiological disease); "pink disease" of the branches (*Corticium salmonicolor*).

The working out of the life history of all the major diseases has powerfully assisted the cause of general estate sanitation and economical working, by insisting on cleaning up the stumps, wide spacing and conservative tapping systems.

Consideration has recently been given to the possibility of insects injurious to cover crops migrating to rubber. Observations tend to show that *Orgyia turbata* is a potential pest where the cover crops mimosa and centrosema are cultivated.

Physiological.—Largely as a result of work on "brown bast" it was felt that a knowledge of the physiology of Hevea was desirable, and in 1920 a plant physiologist was appointed. A consideration of "brown bast" and of yield problems led to work on the physical chemistry of latex as an emulsion and on the biochemistry of the proteins. Other observations were made on yield, tapping systems and related problems.

Chemical.—The principal initial investigations were connected with the coagulation of latex and the preparation of rubber together with some preliminary work on soils. About 1910 it was realised that the problem of preparing the highest quality of rubber for the market could not be studied and investigated satisfactorily without the aid of experimental vulcanising plant. This was purchased in 1913, and from 1914 till the end of the war attention was devoted principally to problems in connection with the causes of variability in the vulcanisation of plantation rubber. This work has formed the basis of a research programme which has since been continued till the end of 1926. Investigations have also been carried out on the storage and ageing of rubber, and more recently on the preservation of latex and the study of rubber prepared from preserved latex.

Agriculture of Rubber.—In 1906, an Experimental Plantation was established in Kuala Lumpur. A considerable portion of this plantation was devoted to the cultivation of Para rubber. Specimens of other varieties of laticiferous trees were also planted including *Castilloa elastica* Manihot spp. and *Ficus elastica*, the native "rambong," but these were found to be of no economic value. In 1905, Hevea test plots were established at different elevations from 300 to 2,400 feet on Gunong Angsi, Negri Sembilan. The results after 10 years showed that comparatively high yields were obtained up to an elevation of 1,200 feet and valuable data were collected regarding tapping systems. It was also found that trees on the most

elevated plot (2,400 feet), although not abnormal latex producers, did not set fruit. Other tapping experiments which were conducted at Government plantations in various parts of the country were instrumental in guiding public opinion to adopt the conservative systems of tapping which are now in vogue on the majority of estates.

Manurial and cultivation experiments have also been carried on for a series of years and have contributed to the present practice on estates, which rely on such cultivation methods as efficient drainage on flat land and prevention of soil wash on undulating land by means of terracing, silt-pitting and the establishment of cover crops, rather than on the employment of artificial manures for the maintenance and augmentation of yields. Special attention has been given to cover crops, and reports have been issued on the suitability of a number of plants for this purpose.

Rice.

As an increase in local production of rice is vital to the country, it was early made a feature of the work of the Department to develop high-yielding strains of padi. Work has been in progress on an experiment station of 21 acres at Titi Serong in the Krian district of Perak since 1912. Similar work was conducted in the Kuala Pilah district of Negri Sembilan from 1914 to 1920. In 1923 another station was opened in Malacca. The results so far available show that under ordinary field conditions the selected strains give an increase in yield up to 30 per cent. above the yield of local rices. Cultural, manurial and catch-crop experiments have been made and are still in progress. Experimental areas have been standardised, many varietal tests have been carried out, special methods of cultivating of " dry " rice have been investigated, milling experiments have been made with various types of mills, pests and diseases have been given attention, and the economics of production and supply have been studied. Little research work on pests has so far been carried out.

Coconuts.

Investigations inaugurated by the Economic Botanist on the property of a large local estate have revealed a wide range of variation in the production of fruit from individual palms grown under uniform estate conditions. Based on these results a selection experiment station has been fully planted with high yielding progeny for further study. The programme of work at this station includes a study of imported and local varieties of coconuts (including dwarf types) in addition to manurial and catch crop experiments.

In the past coconuts have proved remarkably free from serious diseases. Epidemic bud rot due to *Phytophthora palmivora* in its characteristic form has not occurred in Malaya and work on " bud rot " as it occurs locally indicates that the responsible agent is not

Phytophthora but can in many cases be traced to affections of the root and stem which are at present receiving particular attention.

Detailed studies have been carried out on *Rhynchophorus schach* and *Oryctes rhinoceros*; *Plesispa reichei*; *Batrachedra arenosella*; caterpillars of the zygaenid moth *Artona catoxantha*. The Department of Agriculture was closely associated with the introduction to Fiji of the tachinid parasite (*Ptychomyia remota*) to control the allied zygaenid pest—*Levuana iridescens*. The bionomics and control of the spike moth *Tirathaba sp. nr. trichogramma* have been intensively studied during the past two years and the results indicate that the removal of the spathe just before the spike bursts is an effective control for this insect.

Oil Palm.

Early work showed that the germination of seed imported from Africa normally required several months and sometimes extended over several years. It was found that the rate of germination depended on the age of the seed and could be hastened by planting the seed in beds of washed sand and kept thoroughly moist. The most recent experiments show that 80 per cent. germination in 12 weeks can be obtained from fresh seed planted in moist sand beds covered with glass.

Artificial pollination requires to be strictly limited in order to conserve the vigour of the palm, and investigations have shown that when palms attain the age of ten years natural pollination becomes adequate. Work is in progress on general cultivation and on catch cropping with gambier and with bananas. As a basis for the study of varieties and individual palm variation forty different lots of seed have recently been received from Africa.

The pollination of the African oil palm by insects has been studied and results have established the fact that insects play an unimportant rôle in fertilisation.

Problems affecting the yield and quality of the oil and factory methods for the preparation of oil have received attention and a study is being made of the consumption by the oil palm of potash and phosphate from the soil.

Other Crops.

Agricultural Division.

From the inception of the Department small experimental plantations were established in Selangor on which preliminary work was carried out in the cultivation of different species of Coffee, Camphor (*Cinnamomum camphora* and *Dryobalanops aromatica*) and oil palm (*Elaeis guineensis*) in addition to the varieties of rubber already mentioned. As regards Coffee, *C. liberica* thrives on flat lands and *C. robusta* is most suitable for undulating or hilly land; some of the more modern varieties are still under investigation.

Various fibre-bearing plants have been cultivated in small plots

since about 1912, and in larger areas subsequently established at the Government Experimental Plantation, Serdang. In addition attention was turned to the cultivation of roselle, pita or arghan fibre and caraguata fibre. Of these roselle found some favour industrially during the slump in rubber prices in 1921–3, but the remainder have so far not been produced on a commercial scale. Investigations indicate that the cultivation of cotton is precluded by the incidence of pests and diseases.

In 1921 an experimental plantation of 750 acres was opened on the plains at Serdang in the State of Selangor, and recently an area of 75 acres has been opened at Cameron's Highlands at an elevation of 4,800 feet. The station at Serdang is intended for carrying out large scale experiments with the more important crops other than rubber, rice and coconuts, while tea, cinchona, various fruits and temperate vegetables will be established at Cameron's Highlands.

Cover Crops.—As the climate of Malaya is typically that of tropical rain forest to which the cultivation of permanent rather than annual crops is particularly adapted over large areas the conservation of surface soil is a problem of major importance. For this reason a special study has been made of cover crops, of which over 30 species are now under cultivation at Serdang.

Tapioca.—Work on the cultivation of tapioca is in progress at Serdang including a study of the quantity of soil constituents removed in the production of a unit weight of crop. A comparative study of 13 local and imported types is also being made.

Fruit, &c.—The desirability of improving the quantity and quality of locally grown foodstuffs and fruits was early recognised and its importance was emphasised during the rice shortage in 1918-1919. Comparative studies have been made of the yields of 12 varieties of sweet potatoes and 25 races of yams. A number of imported and local types of pineapples have been established for the purpose of selecting those most suitable for dessert and for canning. A botanical classification of 20 local varieties of bananas is proceeding. It is hoped that this work in conjunction with a simultaneous investigation on banana diseases may lead to the discovery of one or more varieties resistant to Panama disease. Little has so far been done on the scientific improvement of local fruits, but a nursery at Serdang has now been stocked with the best types of all the more important kinds and these will form a basis for future studies.

Medicinal, &c., Crops.—The value of locally produced insecticides suitable for general purposes is particularly important to agriculture in Malaya. Tuba root has proved very promising and it has been cultivated by the Chinese market gardeners for many years for its toxic property. Experimental plots have been laid down for the botanical study of the different types recognised and a chemical investigation of their respective toxicities is in progress.

The significant results recently obtained in the treatment of leprosy with chaulmoogra and hydnocarpus oils have led to the planting of experimental areas of *Hydnocarpus anthelmintica H. Wightiana* and *Taraktogenos Kurzii*. Nurseries of both *Cinchona ledgeriana* and *G. succirubra* have now been established on Cameron's Highlands at an elevation of 4,800 feet. Since 1922 experimental plots have been established in which gambier has been grown as a sole crop and as a catch crop with oil palms. Determinations are being made of the fluctuations in tannin content of samples from plots harvested in different stages of development.

Grasses.—A small stock farm is now being started at Serdang. Preliminary investigations on grazing and fodder grasses have been conducted since 1922 as it was realised that most local grasses are of comparatively poor food value, particularly as cut fodder. For the latter purpose guinea grass (*Panicum maximum*) has proved the most satisfactory under local conditions, while dallis grass (*Paspalum dilatatum*) is probably the most suitable for grazing.

Botanical Division.

Among the botanical investigations not already referred to which have been undertaken were the identification of the species of aleurites producing candle-nut and Chinese wood oils : the mistletoes attacking and the epiphytes growing on cultivated trees. Investigations have also been carried out on the flowering and fruiting of the Brazil nut tree, (*Bertholletia excelsa*) and on the betel nut palm (*Areca Catechu* L.) together with observations on the varieties of the betel nuts of commerce.

Selection and breeding experiments with maize, soyabean, groundnuts and coffee are in progress.

Soils Division.

The most urgent need is considered to be a classification of Malayan soils, with special reference to their geological relationships ; until this is done it is extremely difficult properly to utilize results obtained in other countries. The most rapid and reliable means of effecting this classification is considered to be the surveying of selected limited areas. At the same time observations have been or will shortly be started on the following points :—(1) The soil reaction, base exchange, anion retention and availability. (2) Manuring in relation to the soil and plant. (3) The carbon and nitrogen cycles. (4) The flora of the soil. (5) Problems of erosion and leaching. (6) Physical properties of the soil in situ.

The ultimate aim of the Division of Soils is to be able to indicate the parts of the country which are likely to be most suitable for any promising crop other than rubber and the soil treatment which may prove most beneficial. It is hoped that part of this work will be carried out in co-operation with the staff of the Rubber Research Institute.

Chemical Division.

The research work previous to 1921 related almost entirely to rubber. Since that time investigations have been carried out on the nipah palm as a source of alcohol, oil palms and their products, a number of essential oils and other local fixed oils and fats, fibres, raw products for paper manufacture, distillation of local woods for acetic acid, local sources of phosphatic guanos, various indigenous forest products, such as jelutong, damar-resins and gutta percha and many minor agricultural products. At the present time the major problems under investigation are concerned with nipah palm, oil palm, coconuts and the consumption of nutrients by tapioca.

Entomological Division.

Previous to 1920, the attention of officers of this Division was practically entirely confined to the study of " white ants " as affecting the rubber tree and to the control of the locust (*Locusta migratoria*). Since that time, in addition to the investigations on the pests of coconuts, oil-palm and padi already mentioned, the principal work has consisted in obtaining information concerning insects injurious to all plants in Malaya.

At the present time the economic importance of the aleurodids is being studied and attention is being paid to the insects of areca and nipah palm.

In the near future it is hoped to commence studies on *Prays citri* —a rind caterpillar pest of citrus—the Cerambycid " borer " (unidentified) of Cloves and the Laciferous insects of Malaya.

Mycological Division.

At the present time a study is in progress of the various species of *Phytophthora* of pathological importance in Malaya. In this connection results have been published on a disease of sireh (*Piper Beetle*) which has been shown to be due to a *Phytophthora sp.* The diseases of bananas are also under investigation with a view to finding a variety resistant to Panama disease.

Sclerotial diseases on commonly occurring roots and cover crops have received attention and work is now in progress on a disease of the areca palm and a disease of citrus.

The Field Division.

It has always been a function of the Division to study local agricultural conditions and requirements and to keep the Research Officers informed of these. The Division has also served to keep the Research Officers and the planting public in touch with one another. Part of its instruction duties involves the establishment and running of small padi stations for testing and demonstrating the suitability of selected strains. A padi experiment station of 22 acres in Malacca

is supervised by the Agricultural Field Officer under the guidance of the Economic Botanist. The Division is also in charge of two small experimental stations principally used for the local cultivation of fruits and cover crops to supply material for distribution.

FIJI.

Research into sugar cane problems is dealt with by the Colonial Sugar Refining Company.

Research into other problems is undertaken by the Agricultural Department, which has a Superintendent, Chemist, Entomologist, Mycologist, three Veterinarians, Rice Mill Manager, Cotton Inspector, Cotton Specialist (this Officer's salary is met by the Empire Cotton Growing Corporation), Inspector of Produce, and three Inspectors of Plantations; and, in addition, a small staff dealing with coconut problems, this staff consisting at present of two Entomologists, an Agronomist, and a Field inspector controlled by a special committee, and financed by a small export tax on copra, plus an equal sum from general revenue. The Department of Agriculture and the Coconut Committee are intimately co-ordinated, and for practical purposes function as a single unit.

Coconuts and Copra.—The most serious problem was presented some years ago by the Purple Moth of Coconut Palms, *Levuana iridescens*. Entomologists were sent to New Guinea, Java and the Federated Malay States to study the parasites of related host insects, and to bring to Fiji the more important parasites of *Artona catoxantha*. This resulted finally in the establishment of a parasitic two winged fly, *Ptychomyia remota*, the success of which has been phenomenal.

The question of coconut breeding has been taken up. A method has been devised of keeping pollen viable for about ten days, and this has enabled a number of crosses to be made. For the present, an attempt is being made to develop three pure lines—(*a*) a hurricane resisting cross between the Fijian dwarf and the Malayan dwarf or King; (*b*) a high copra yielding strain of the Rotuman coconut, and (*c*) a high copra yielding strain of the tall native coconut.

Steps are now being taken to introduce parasites and predators of the coconut scale *Aspidiotus Destructor*, two species having been landed successfully from Java.

The Mycologist has commenced a study of the Budrot disease of Coconuts.

Bananas.—The Mycologist has shown the leaf spot disease of bananas in Fiji to be due to *Cercospora musae* Zimm.

A study is being made of the banana borer—*Cosmopolites Sordidus*—and the predatory beetle *Plassius javanus* has been established.

An experiment has been undertaken to ascertain to what extent beetles fly to uninfested plants.

Sulphur lead-arsenate dust has proved efficacious in the control of the banana scab moth, *Nacoleia*.

Cotton.—Sea Island Cotton has done well, and has given a good return to growers, but the market is so limited that adequate returns cannot be depended upon. A cotton experimental station has, therefore, been opened, through the co-operation of the Empire Cotton Growers' Corporation, in the Sigatoka river valley, for testing varieties that command a lower price, but have a wider sale than Sea Island. The first planting was made in November, 1926, and the varieties under test or about to be tested are Meade, Sakel, Pima, Peruvian, a local hybrid, and a New Guinea strain of Kidney. Single plant selections are also being made of Sea Island in order to keep the variety true to type.

Rice.—Mass selection tests are being carried on with a number of varieties of rice, with a view to maintaining the standard of strains grown locally.

Trials are being made of various tropical grasses and fodder plants. A pineapple-growing and canning experiment has given very promising results.

GAMBIA.

The most important crop is groundnuts. A certain amount of rice and other foodstuffs is grown, but not in sufficient quantities to meet requirements, and the country is dependent to some extent on imported foodstuffs, paid for by exports of groundnuts. The quality of the nuts has recently reached a low standard both on account of adulteration and high free fatty acid content. Agricultural policy is therefore directed to removal of adulteration, improvement of quality and increase of output of groundnuts, to increase of the production of local foodstuffs and to the introduction of new crops. So far as investigational, &c., work is concerned, it is sought to establish agricultural stations where field trials and experiments can be carried out with a view to general recommendations ; to make a general collection of tropical plants of economic value with a view to propagating them for general distribution and cultivation ; and to study and control insect and fungus pests.

Work is carried out on varieties and manuring of groundnuts at the Agricultural and Botanical Station, Cape St. Mary. The chief diseases coming under notice are rosette disease and leaf spot of groundnuts, and smut of corn.

GOLD COAST.

The chief crop of the Colony is cocoa. The soils, on the whole, over a considerable area of the cocoa belt seem to be excessively rich, but in places are stony and elsewhere would be called poor. Yet they have produced good crops for many years with no addition to the soil to replace material removed with the crops. The question is how long this can go on without reduction in crops or the employment of methods to counteract the loss of soil matter. These questions involve a study of soils and of the effects of manures.

The Incidence of Disease.—The effects of disease are becoming more apparent as time goes on, and particularly where cocoa has been planted on unsuitable sites. Problems for investigation are the best sanitation methods on the farms and the selection of resistant strains and propagation by budding, &c.

Cocoa Planted on Unsuitable Land.—Much cocoa exists which has been planted on unsuitable soil. The plants struggle along, give small crop, and the trees die off one by one. There is a danger that such areas may be centres for the spread of disease; yet they are of commercial value, and the problem is how best to deal with them in their present state and when they die out.

Mould in Cured Cocoa.—This is a troublesome matter, since there seems to be a ready sale for cocoa no matter what its quality may be. The questions involved are: (*a*) Entry of the mould into the shell; (*b*) conditions permitting growth of mould; (*c*) methods of storage to keep cocoa sound.

Insect Pests.—Problems requiring investigation are the relation of damage done by insect pests to reduction of forest, quality of soil, climatic conditions, &c. *Sankonuabe* is a most troublesome insect pest. The question is whether it is indigenous or not, and methods of control by natural enemies or otherwise are required.

The Rainfall.—Cocoa grows in the Gold Coast under a smaller rainfall than in most other cocoa countries. It is required to determine the effective amount of rain and its influence on the crops.

The Cocoa Plant.—General problems are the fertilization of the cocoa flower, the variation in time from flowering to harvest crop, the best distribution of pickings of the crop to avoid loss by diseases, the variation in crop and season of crop with age of trees, and the length of life of the cocoa tree in the Gold Coast.

Oil Palm Industry.—Investigation is required of the best method of reviving this industry in such a way as to compete with the plantation industry in the East, including (*a*) establishing plantations of better varieties, (*b*) encouraging the construction of mills.

Cotton Industry.—Work is needed on the selection of types of cotton best suited to the two areas in which cotton is likely to do

best, (*a*) the Northern Territories, (*b*) the mandated area of British Togoland.

Food Crops.—Methods by which the cost at which local foodstuffs are sold in the large markets may be reduced requires investigation.

It is difficult to ascertain what has been and is being done in tropical agricultural research. The requirements of the entomological and mycological branches are fairly well provided for by the reviews of current literature published by the Imperial Bureaus of Mycology and Entomology. Publications on similar lines are required to provide for the requirements of botanical, chemical and general agricultural workers.

A *résumé* of what has been accomplished with all the various tropical crops is highly desirable. Information at present is scattered through large numbers of publications of many countries, and it is practically impossible for the tropical possessions, particularly the smaller ones, to collect the complete series.

JAMAICA.

The following is a brief account of the programme of agricultural research in Jamaica.

Banana Industry.—Study of fusaria in soil in relation to "Panama Disease." Methods of control for this disease in relation to field operations. Resistant varieties—cross-fertilisation of bananas. Production of seedlings and selection of immune varieties suitable for commercial cultivation. Field trials of known varieties of bananas. Experiments on the ripening and shipping qualities of new bananas.

The insect pests of the banana. Field methods for the control of the banana borer weevil. Study of dangerous pests of the banana in countries other than Jamaica.

Sugar Industry.—The breeding, selection and estate trial of new sugar canes. Co-operative field experiments on estates for testing new canes in comparison with standard varieties and in manuring with artificial manures. The control of mosaic disease. Immune and resistant varieties of cane. The yeasts of rum. The fermentation processes in the manufacture of Jamaica rum. The high ether process and rums of high flavour for blending.

Coconut Industry.—Diseases and pests of the coconut in Jamaica and their control. The manufacture of copra and of coconut oil.

Cacao and Coffee Industries.—Pests and diseases and their control.

Fibre industry.—Tests of sisal and henequen on a practical scale as crops for areas with low rainfall which are unsuitable for other cultivated crops.

Pimento Industry.—The manufacture of pimento leaf-oil and a study of the conditions affecting the percentage of eugenol in the oil.

Mangoes.—The budding and production of superior varieties of mango for export.

Pineapples.—The trial of varieties of pineapple for purposes of export.

Citrus Fruits.—Study of the diseases and pests of citrus trees and field methods of control. The improvement of methods of packing and shipment.

Livestock Industry.—Control of ticks by compulsory dipping. Manufacture and general distribution to the public of an economical arsenical dip. Animal diseases and their control. The improvement of native cattle, horses and asses by means of a public stud farm and a government stock farm. Study of the dairy industry under tropical conditions. The development of productive tropical dairy cattle and the issue of improved stock to the public. The use of silos. The growing of fodder crops. Control of Tick Fever by the use of Trypan Blue. The sanitary production of milk. Practical methods of butter production.

Horticulture.—The production of new varieties of garden plants by hybridisation.

KENYA.

The agricultural research work in this Colony falls into two main divisions, veterinary and agricultural, both under the control of the Director of Agriculture.

The former is concerned entirely with research and investigation into the livestock diseases of the Colony.

The latter consists of the sub-divisions of Agricultural Chemistry ; Agricultural Entomology ; Agricultural Mycology ; Plant-Breeding ; and Coffee.

In addition the work of veterinary research is supplemented by a staff of veterinary officers and stock inspectors at work throughout the reserves and settled areas and that of agricultural research by a staff of agricultural officers in the native reserves and a plantation inspector and coffee officer in the settled areas.

Veterinary Research.

The Veterinary Research Laboratory is situated at Kabete, 8 miles from Nairobi. The staff comprises 4 veterinary research officers.

The technical routine carried out at the Laboratory comprises :—(1) The manufacture of antirinderpest serum, vaccines and other laboratory products for the prophylactic treatment of diseases ;

(2) The control of animals used for serum and vaccine producing and experimental purposes ; (3) Immunisation (in conjunction with the Veterinary Division) of imported cattle against Redwater-Gallsickness ; (4) Examination of slides and specimens sent in by veterinary officers, stockowners and others.

Generally speaking, the research work has been directed towards (1) the introduction and perfecting of a method of immunisation against the diseases which are of most economic importance, the application of such having been found to be the most satisfactory means of protecting the greatest number of animals exposed thereto, and (2) extending knowledge of these.

Research has been particularly concentrated on (1) Rinderpest ; (2) Bovine Pleuro-pneumonia ; (3) East Coast Fever ; (4) Redwater and Anaplasmosis ; (5) Anthrax ; (6) Blackquarter ; (7) Blue-tongue of sheep ; (8) Intestinal parasitic infections of sheep ; (9) *Psoroptes communis ovis* ; (10) Calf diseases ; (11) Streptothricosis ; (12) Swine fever.

Research work in animal nutrition is at the present time proceeding in the Colony directed by the Rowett Institute and is under Imperial auspices. Four officers from the Rowett Research Institute are conducting feeding trials with cattle and sheep at four different centres in conjunction with stock owners.

Agricultural Research.

There is one central station, namely, the Scott Agricultural Laboratories, 4 miles from Nairobi, and 3 miles from the Veterinary Research Station, Kabete.

The buildings comprise entomological laboratory with breeding sheds, chemical laboratory and store, mycological laboratory and store, plant breeder's laboratory and large offices for the various scientific officers working there.

Chemistry.—Agricultural chemical research in Kenya was commenced by the now defunct Chemical Research Department. In 1924 a chemical section of the Agricultural Department was established. Work is being carried out on manuring in general, the effect of nutrients on coffee, green manuring for coffee, control of the strength of arsenical dip washes, the fermentation of coffee and the relationship between plant associations and soil types.

Entomology.—Work has been carried out on a ground beetle (*Conocephalum*), wheat aphis, coconut beetle, insect pests on coffee and tsetse fly.

Mycology.—This work has related to coffee berry disease, coffee die-back, the influence of micro-organisms on the deterioration of fabrics, water retting of flax, and sugar-cane mosaic.

Plant Breeding.—Plant breeding has been mainly concerned with the production of suitable wheats. The main problem is the

production of high-yielding varieties immune to the three rusts, *Puccinia triticina*, *Puccinia glumarum*, and *Puccinia graminis*.

As regards *Puccinia glumarum*, the wheat "Kenya Governor," while by no means immune, is sufficiently resistant to form a useful stop-gap until more resistant wheats are found; its milling qualities are excellent and its yielding capacity good. In addition, the progeny from some hybrids from America show signs of being immune to *Puccinia glumarum*, and are being multiplied for issue. During the last six years, also, many crosses have been made, some of the progeny of which show signs of immunity or at least sufficiently high resistance either to *Puccinia graminis* or *Puccinia glumarum* or to both. Some of these are now pure and are being multiplied for issue as rapidly as possible. As there are no indigenous wheats resistant to *Puccinia graminis*, some hundreds of thousands of hybrid plants have been tested out year by year at two different stations for resistance to *Puccinia graminis* or to *Puccinia graminis* and *Puccinia glumarum* in the endeavour to find a few plants which combine high resistance and suitable agricultural and milling qualities.

Other plant-breeding work relates to maize and coffee. An attempt is being made to fix a type of "Flat White" maize possessing both high yielding power and high commercial quality.

Selections have been made of bronze-leaved types of coffee which have shown particular hardihood and bearing qualities in certain districts.

Collections have been made of indigenous and foreign plants suitable for use as green manure, and their behaviour has been studied under local conditions. A large collection of indigenous grasses has been planted and is kept under observation, and specimens have been forwarded to Kew Gardens for identification. Native fibre plants of various kinds are also under observation.

LEEWARD ISLANDS.

Introduction.—The colony of the Leeward Islands, consisting of the presidencies of Antigua, St. Kitts-Nevis, Montserrat, Dominica and the Virgin Islands, although only 716 square miles in area, exhibits considerable differences in physical features, in soil and in climatic conditions, and as a result the agricultural interests of the colony are of a somewhat diversified nature. In Antigua and in St. Kitts sugar is the main industry, while Sea Island cotton, which is now the chief crop grown in Nevis and Montserrat, occupies the second place. Dominica, which differs considerably from the other islands of the colony and geographically is classed with St. Lucia and the French Islands of Guadeloupe and Martinique, has for many years been the centre of the West Indian citrus industry and indeed

the chief source of lime products in the world. In the last few years, however, the advent of withertip of limes has made impossible the cultivation of the West Indian lime in many parts of the island and attempts are being made to grow other crops. notably coconuts, ginger and vanilla.

Agricultural Organisation.—In each presidency there is a local Agricultural Department, the staff in most islands consisting of the Agricultural Superintendent. who is also Curator of the Botanic Station, and two or three locally trained assistants. In Dominica the department is more strongly staffed. there being two assistant Agricultural Superintendents (Kew trained). There is a Federal Department of Agriculture with headquarters in Antigua. The staff consists of two qualified officers—the Government Analytical and Agricultural Chemist, who is also Superintendent of Agriculture for the Colony, and an Assistant Chemist. The functions of this Department are advisory to the local departments and in addition most of the research and other chemical work of the Colony is carried out by its officers.

The Agricultural Departments have the advantages of consulting with the staff of the Imperial Department of Agriculture for the West Indies, which since 1922 has been amalgamated with the Imperial College of Tropical Agriculture.

Sugar cane.—The chief disease attacking the crop is the root disease complex. Rind fungus (*Melanconium sacchari*) and red rot fungus (*Colletotrichum falcatum*) also occur. Pineapple disease (*Thielaviopsis paradoxa*) attacks cuttings.

The chief insect pest is the small moth borer (*Diatraea saccharalis*). An attempt is now being made to control this pest by the introduction through the Imperial Department of the hymenoptera ipobracon and microdus, which are parasitic on the larval stage.

Varietal experiments have been conducted in St. Kitts, Nevis, Antigua and Montserrat. This work includes new varieties immune to or resistant to gumming disease.

Manurial experiments with sugar cane have been carried out at stations both in Antigua and in St. Kitts.

Sea Island Cotton.—The present Sea Island cotton industry dates from 1901, when experiments were commenced at the Botanic Stations in Antigua and Montserrat and about twenty acres were planted in St. Kitts. Thereafter, the industry developed rapidly, and is now the chief industry in Montserrat and Nevis.

The chief pests and diseases are the cotton worm (*Alabama argillacea*), the leaf blister mite (*Eriophyes gossypii*), the flower bud maggot (*Contarinia gossypii*), the cotton stainer (*Dysdercus andreae*) and the pink boll worm.

Seed selection work has been carried out ; and manurial experiments with cotton have been conducted in Antigua, Montserrat and St. Kitts. The results for the whole colony indicate that the applica-

tion of artificial manures is not remunerative but that the humus content of the soil must be maintained by applications of pen manure.

The Citrus Industry.—This industry is important in Dominica. Two serious diseases are " die-back," due to too great a variation in atmospheric humidity and soil moisture ; and withertip or blossom blight, caused by the fungus *Gleosporium linetticolum* (Clausen), and varying in intensity with moisture conditions.

In connection with withertip, visits have been paid to Dominica by mycologists from the Imperial College of Agriculture for the West Indies, from the Trinidad Department of Agriculture and from the Bureau of Mycology, and in 1923 the Assistant Agricultural Superintendent visited Florida to study the methods of control used there. It is now realised that owing to the high rainfall and to the rugged nature of the island, spraying with Bordeaux mixture or other fungicide is impracticable, and that the sole hope of continuing lime cultivation in the wetter districts lies in the selection of a suitable immune or resistant variety. Experimental plots have been started on the point.

Attention has been given to the chemistry of lime products (citric acid, lime seed oil, citrus pectin and lime oil) at the Federal Laboratory in Antigua and the extension of the production of by-products has been advocated.

Cacao.—During recent years the production of cacao has decreased considerably.

Phytophthora pod rot, known locally as black pod, and the canker also due to *Phytophthora Faberi* are prevalent in the humid districts, especially during the wet season, and Rosellinia root disease is not uncommon. Cacao grown in situations exposed to the wind and insufficiently shaded frequently suffers from die-back. A pod rot due to the same fungus and known locally as brown pod rot is also of frequent occurrence. The most important insect pest is the cacao thrips (*Heliothrips rubrocinctus*).

Experiments conducted over a number of years at the Botanic Gardens in Roseau have shown that a system of mulching with decaying vegetable matter has maintained vigorous growth of cacao orchards.

Coconuts.—The chief insects attacking the crop in the Leeward Islands are scale insects, principally *Aspidiotus destructor* and the coconut white fly (*Aleyrodicus cocois*).

MAURITIUS.

1. Survey of Conditions.

Mauritius is a small island in the Indian Ocean 500 miles to the east of Madagascar. It possesses an extremely fertile soil and an annual rainfall ranging between 140 inches in the wettest districts and 30 inches in the driest. The principal crop is cane sugar, the average annual production of which is 230,000 metric tons.

From the year 1893 until 1913 a small agricultural research station was maintained by the planters at their own expense, under the title of the Station Agronomique. In 1913 the Station became merged in the Government Department of Agriculture established in that year. In 1921 increased facilities were provided for teaching and research owing to the efforts of the sugar planters.

The Department of Agriculture is organised in 11 divisions; and the College of Agriculture is worked as an integral part of the Department. The grounds of the Central Experiment Station at Reduit in which the Department of Agriculture buildings are situated are approximately 55 acres in extent; of this about 30 acres are under experimental cultivation and 25 acres are occupied by the Stock Farm. There are two subsidiary experiment stations, one at Pamplemousses, distant 16 miles from Reduit, and the second at Beau Bassin, distant 5 miles from Reduit. In addition there are a number of substations on estates which are worked in co-operation with the Department.

At Curepipe, distant 9 miles from Reduit, is situated the Government Dairy, which is designed and worked on approved modern lines.

Three Government Botanical Gardens, at Pamplemousses, Le Reduit Government House, and Curepipe, are also supervised and worked by the Department of Agriculture; they are of considerable area and antiquity and contain notable collections of tropical plants.

The Colony offers special attractions and advantages as a centre for extension of research in its Imperial aspect with special reference to sugar. The climatic and soil conditions and geographical situation are particularly favourable; there is an absence of the more important cane diseases; there is regular and frequent mail steam connection with Europe and East Africa; the sugar industry is operated on modern lines, by an intelligent and progressive personnel; and there is a well-established and equipped institution for agricultural research.

2. Work of Divisions of Department of Agriculture.

Chemical Division.—Investigations have been carried out into the composition of exhausted molasses, the deterioration of sugars in storage, the application of molasses to cane soils, manurial and variety trials of sugar cane.

Studies on soils have related to the absorptive power of Mauritius

soils, a soil survey of the island, the behaviour of nitrates in the soil, the losses incident on preparing farmyard manure, the manurial value of commonly occurring organic substances, the changes occurring in phosphatic manures in the soil after application, and the remarkable infertility and toxic nature of the subsoils of the Colony.

In relation to other crops, work has been carried out on tea, tobacco, essential oils, and feeding value of fodder crops.

In relation to animal husbandry, an investigation has been made of the composition of local milks.

Sugar Technology Division.—Little work has been accomplished, but there is abundant need for research. There is hardly a stage in the whole process of sugar manufacture which does not offer a field for useful investigations.

Entomological Division.—Research work carried out by this division relates to the following :—moth borers affecting sugar cane ; insects attacking stored grains ; grubs attacking sugar ; the introduction and acclimatisation in Mauritius of *Tiphia parallela* as a parasite of Phytalus ; the demonstration of the parasitism of the Madagascar wasp *Scolia Orystophaga* on the locally occurring *Oryctes tarandus* (a serious pest of cane), and its subsequent acclimatisation in Mauritius ; scale insects of the Colony ; the cutworm *Prodenia Litura* ; the life cycle and breeding habits of *Stomoxys nigra* believed to be the vector of surra. A considerable amount of work has also been done and is in progress on various intestinal and blood parasites of farm stock and poultry, and a small amount of work on the soil-inhabiting protozoa, a member of the staff having specially studied technique in this connection in England.

Botanical Division.—The work so far accomplished by this division comprises the life history and description of the principal phytopathological diseases affecting the sugar cane in Mauritius. Work is also in progress on the life history and description of diseases affecting other economic plants. Some work has also been accomplished on certain physiological questions ; thus measurements have been made of the transpiration ratio and of the rate of growth of the sugar cane.

Veterinary Division.—The research work undertaken by this division is limited. It has comprised a survey of the principal animal diseases of the Island and some investigations on the occurrence of bovine tuberculosis and on surra.

Statistical Division.—The cost of production of sugar in Mauritius was worked out in 1918. A correlation has been worked out between seasonal conditions and cane yields, and an investigation of the probable error of field trials made. The Statistician has control of the meteorological service of the Department.

Agricultural Division.—The experimental work has comprised a large number of manurial and cultural experiments with canes, the breeding and trying out of new varieties of canes, and the irrigation of canes under Mauritius conditions.

Tobacco Division.—Investigational work has included trials with a number of varieties of tobacco and the establishment of the types most suitable for culture, manurial experiments, trials in curing and especially the demonstration of the local applicability of flue curing methods. Work in hand comprises further manurial trials, further variety trials and the improvement of existing proved varieties by mass selection and progeny plot methods.

NIGERIA.

1. Organization of the Department of Agriculture.

There are two centres for laboratory research work, one in Southern Nigeria at Ibadan, and one in Northern Nigeria at Zaria. At Ibadan there are stationed chemists, botanists, mycologists, and entomologists, but at Zaria there will be chemists and botanists only. Both laboratories are on an experimental farm ; at Ibadan are also the Director's Headquarters and the Department's agricultural school ; and at Zaria are the Headquarters of the Assistant Director of Agriculture and his Deputy, who are in charge of the agricultural work in the Northern Provinces. In addition to these two headquarters farms there are six other experimental farms. Each of these farms is over one hundred miles from the next, and the climatic and soil conditions at each farm are very different : so far as possible each farm was so selected as to be typical of the area which it serves. The conditions in Southern and Northern Nigeria are so different that two separate research centres are necessary. Indeed even within the Northern Provinces or Southern Provinces the conditions vary so much that logically a case could doubtless be made out for even more research stations ; but in compromising between the advantages of centralisation and dispersion, two main centres appear to be the right number, and there is no intention of increasing this number. It is proposed gradually to increase the number of the ordinary experimental farms until there is one for each part of the country which can be regarded as a " unit area," which is such that climatic variations from place to place within it are not great, and extension work within it can be managed from one centre. Roughly each farm serves an area of 5,000 to 10,000 square miles. As there are many thinly populated parts of the country which at present would hardly repay intensive effort, it is estimated that some 13 or 14 stations would provide fairly satisfactorily for the requirements of the whole country.

While the organisation of the Department is thus on a territorial basis rather than on a subject basis, there is rather more specialisation than appears. More sub-division on a " subject basis " may become necessary in time ; but the present organisation is satisfactory for the present and the immediate future.

It will be convenient to deal first with the field experiments at the experimental farms ; for this is the central part of the Department's work. Each experimental farm is managed by a staff of three agricultural superintendents, who are graduates of various British universities and agricultural colleges. Each farm provides about 100 acres of land suitable for experiments, in addition to some plots which are cultivated, but are unsuitable for experimental purposes. The most senior officer of the farm is responsible for the extension work in the district as well as for the management of the experimental farm and the accuracy of the results. This arrangement is not merely dictated by practical necessities, but is deliberately chosen in order to provide the closest connection between the extension work of the Department and the experimental work.

2. Investigational Work.

Field Experiments.—The field experiments may be classified as

(*a*) practical details of farming practice under local conditions, such as planting distances, planting dates, frequency or depths or method of cultivation, the relative exhaustiveness to the soil of various local crops, the practicability or economic returns from various systems of catch-cropping or inter-cropping with local crops. In the Southern Provinces both annual and permanent crops (oil-palm, cocoa, kola, &c.) are studied. This type of experimental work is not so necessary in many countries as it is in Nigeria, where local practices are so variable and often ill-defined, that the study of such questions by definite field experiments is essential.

(*b*) tests of pure or improved strains of local crops evolved by Departmental plant breeders, or other suggestions put forward by the specialist research workers.

(*c*) study of methods for the maintenance of the fertility of the soil at a high level under local conditions. In this connection a very broad and thorough series of experiments on green manuring in regular rotations has been carried out for three or four years (and is continuing) at four stations in Southern Nigeria. In the Northern stations, where the climatic conditions are favourable to stock farming, the economic and practical problems involved in mixed farming are being studied in the same way and with the same object.

The field experiments at each station are in general so designed that, though the work at each farm is adapted to local conditions, it also generally serves to confirm or amplify the work at the next farm, where the conditions are not totally dissimilar. Experiments are laid out on modern lines on long $\frac{1}{4}$-acre plots with an adequate number of repetitions, and with an adequate system of checks and records. Labour costs are carefully recorded for every plot.

Chemical Investigations.—A staff of four European chemists, with the necessary native assistants, is already provided for, and the appointment of a fifth is contemplated in the near future. A sixth will probably be needed before very long ; but it is considered that six agricultural chemists should be adequate to the needs of the country for a number of years, if the native staff can be raised to a sufficiently high level in numbers and quality. Of these six, two are, or will be, employed on soil science at Ibadan and two at Zaria. Their main duty will be work in connection with the field experiments connected with the maintenance of fertility referred to above, and soil analysis or examinations in connection with extension work in the same subject.

One of the three chemists actually appointed already has been solely occupied on work in connection with palm oil and kernels and ground-nuts. It is probable that it will be necessary and possible to devote two chemists to such organic chemistry on problems of a commercial nature in connection with the preparation and marketing of the products of the various local crops. There is still important work remaining to be done in connection with palm oil and kernels, and there are numerous products which would require some examination from the chemical point of view, especially in connection with the work of the plant breeders.

Plant Breeding.—A staff of four European economic botanists is sanctioned—two for the Northern and two for the Southern provinces—though, unfortunately, owing to transfers, invaliding, &c., the staff actually at work has never yet exceeded two ; it is expected that a full complement of men, who will be permanent, will be available before the end of 1927. Their main duty is plant breeding. So far they have been able to do little beyond cotton breeding ; but some preliminary work has been done in connection with oil-palms, groundnuts, yams, guineacorn and edible beans, which preliminary work, it is anticipated, will render rapid progress possible as soon as the staff is complete. Some work has been done, and more is contemplated, on various lines of investigation with the objective of indicating the type of plant to be aimed at in the plant breeding—such matters as the study of physiological factors limiting yield, and the characters which render the plant immune to local diseases. A little purely physiological work has been done in connection with the oil-palm with this object.

Entomology and Mycology.—Two European entomologists and two European mycologists are stationed at Ibadan, though they move to other stations when necessary. It is considered that this number, with the necessary native assistants, should be adequate for the country's needs for some considerable time. For several years these officers were mainly employed on the statistical estimation of the relative importance of the various diseases and pests limiting the yield or damaging the quality, of cotton in Southern Nigeria. The main object again was to indicate the type of cotton best suited to the country, which should be produced by the plant breeder. This work has now been reduced at Ibadan, as being almost completed, but it is proposed to study in the same way the disease factors in each of several other provinces where diseases of cotton are numerous and serious. In addition to this work, a considerable amount of work of the ordinary nature, —bionomics of insects, inoculation experiments with fungi—has been done. Such work here is, however, limited by the fact that there are only certain types of control measures, such as the introduction of parasites, sterilisation of seed, breeding of immune varieties of plants, and some types only of plant sanitation measures, that could possibly be practically applicable in local conditions. Many of the types of control measures which require continued and very careful work by the individual farmer, or the employment of poisons and sprays, &c., are out of the question in this colony. The entomologists and mycologists are now beginning to extend their investigations to local food crops.

3. Co-operation with Other Colonies.

Some of the lines of work mentioned, such for instance as the experiments on green manuring, the botanical work on oil-palms and yams, the entomologists' and mycologists' work on the spread of internal boll diseases by cotton stainers, and the oil chemists' work on palm oil extraction, should be of use or interest to other colonies; and some parts of the work might even be said to be almost of the nature of "fundamental research work." The work has not been undertaken from these points of view, but simply on account of its local economic importance. Any work which is not of obvious economic importance has to be secondary to work on immediate economic problems; it has to be practically "spare time" work. There will be little opportunity for such work for some years.

On the question of fitting in the Nigerian work with the work in other colonies in West Africa or in the West Indies there would not appear to be any lack of co-ordination or duplication so far as Nigeria is concerned. In fact several lines of work of very considerable local economic importance have been left entirely alone in the hope that similar work in other colonies will help, or very greatly narrow down, the problem for Nigeria. In this category the breeding, grafting

and diseases of cocoa might be mentioned. On the other hand, some lines of work in Nigeria do not seem to have been studied very extensively elsewhere, presumably because they are of less economic importance. A West African Agricultural Conference was held at Ibadan this year; and it is hoped that this will be the first of a permanent series. Such conferences will do a great deal to provide co-operation and "co-ordination" of a most practical kind.

Under the present arrangement it is possible for work of immediate economic importance to be practically left alone by every colony in the hope that some other colony will take it up. It must also be admitted that there is no provision for agricultural research work of a "fundamental nature," *i.e.*, work which, while dealing with crops, yet has the ascertaining of the truth as its sole objective, irrespective of any obvious immediate economic value of that knowledge, beyond its significance in the education of workers on economic problems. There are many lines of work that might be cited in this category. One of the most important appears to be the study of the weathering processes in soils under tropical conditions; another, soil bacteriology in tropical soil; and there is a whole wide field for investigation in the physiology of tropical crops. The only way in which Colonies can afford to provide for such work—using the word "afford" to cover both the financial question and that of non-interference with other work—is in connection with Agricultural Colleges.

NORTHERN RHODESIA.

Little research work has been done in agriculture in this territory in the past, although a vast amount of observation of the behaviour and requirements of a number of crops has been carried out, to a large extent by the farmers themselves.

Without exception, the crops grown in the territory by the European farmers for sale are exotics; while the farming community knows many crops which it is possible to grow in the territory, no reliable data are available as to the best seed, cultivation, control of diseases and insect pests, and the best method of handling and marketing.

The facts that the territory is totally land-locked, that the cost of railage to the coast of other territories is high, and that the produce consumed locally or in the Congo has a limited market, reduces the number of crops which can be grown profitably for export to such as are of high value and small bulk. In this category are included such crops as tobacco and cotton. For local markets maize, beans, and citrus fruits are grown: it is with the multitudinous problems pertaining to these that research must immediately concern itself, and with endeavouring to add to the number of crops that may profitably

be grown. The tendency is for the farmer to confine himself entirely to the growing of one crop. To avoid the risks attendant on this practice research must devise suitable rotations.

Many of the soils in the farming areas (particularly of the lighter sandy types) appear to be lacking in humus, and there is also some evidence to show that they are deficient in phosphates. Little or no attempt has been made to utilize cattle manure to remedy the deficiency. Cattle are reared on ranching lines and graze extensively on the open veldt. Investigation is needed of methods of increasing the feeding value of maize straw and of securing its increased use as fodder. The cattle being grazed on the open veldt, the manure which accumulates in the kraals in which they are confined, in some places, during the night, contains vast numbers of weed seeds. Any methods of storing, treating and handling even the small quantity of manure which is customarily collected, that would offer a possibility of freeing it from the burden of weeds which follows its use, are worthy of the fullest investigation.

Investigations on green manuring are also required. There is already in the country a wealth of plants suitable for forage crops and for clean grazing which, if utilized for feeding cattle under a more intensive system, would both increase the quantity and the quality of the manure, and it remains for research to investigate these plants to discover which are of the highest feeding value and most likely to prove profitable to grow. In the more settled areas investigation is now urgently required into the methods of utilising artificial fertilisers, the materials and quantities most beneficial to the different crops, times of application and effect on the soils to which they are applied. In a country such as this with such a superabundance of vegetable matter on every side, on the farm, in the veldt and in the forest, local methods of manufacture of synthetic organic manure on the lines now being worked upon at Rothamsted and elsewhere might be evolved with great advantage to agriculture.

That much research work in agricultural problems, a few of which are outlined in the above, is necessary is generally admitted and in order that it may be carried out a combined Agricultural and Veterinary Research Station is now in process of being established at Mazabuka on the railway in the centre of a group of farming areas. It may be possible later to open sub-stations at points within areas where considerable divergence of climatic and soil conditions from those of the Central Research Station exists. Such areas are those of the Congo Basin and the tobacco-growing areas in the East Luangwa District.

For solution of the problems of a highly scientific interest demanding work of an intricate nature, this country, in the present state of her resources, must continue to look outside, and in this connection it is hoped that the Amani Institute with its greater facilities will be in a position to give much valuable help with many of the problems,

particularly with those relating to pests and the means of controlling or evading them.

A botanical survey of the Territory, to deal primarily with the classification of the chief types of vegetation in relation to the climate, rainfall and soil types of their habitats, would be of the greatest use as a preliminary guide to the possibilities of development of certain branches of agricultural activities in particular localities.

The following is a summary of some of the more immediate and important objects of research grouped under crop headings as follows :—

Cotton.—The production of a strain or strains specially suitable for local climatic and economic conditions either by selection from varieties already in the country or by selection from new importations: investigation into the possibilities of breeding varieties resistant to the effects of jassid and aphis : the evolving of methods for controlling or evading certain pests, the most important of which are the Red Boll-Worm (*Diparopsis castanea*), which is the major cotton pest in one district, the internal boll-rots caused by the stainers (*Dysidereus* spp.), which appear to be almost universally distributed wherever cotton is grown, the American Boll-worm (*Chloridea obsoleta*) and the Spiney Boll-worms (*Earias* spp.), which are almost equally universally distributed.

Tobacco.—Variety trials to determine the most suitable varieties for various areas and selection work in those varieties to improve them. Investigation of curing methods to determine if these can be improved upon and if economies of fuel can be effected : of cultural methods with a view to increasing production and effecting economies in the use of hand-labour particularly, and investigation into the uses of artificial fertilisers with special reference to this crop and the type of soil on which it is usually grown.

Maize.—Improvement of the varieties now in common cultivation and the maintenance of nucleus stock of improved seed for continuous issue. Investigation into cultural methods with the object of determining how the cost of production may be decreased and into the local manurial requirements of this crop.

Wheat.—The control of rust or the production of rust-resistant varieties.

Green Manures.—The relative merits of the numerous indigenous and exotic crop-plants suitable for the purpose.

Fodder Crops and Grasses.—The value of various indigenous and exotic grasses for fodder and grazing. The improvement of veldt grazings.

Citrus Fruits.—Successful methods of growing citrus are different from those employed in more temperate climates and an investigation

of the whole question of cultivation and handling, including the control or avoidance of insect pests, is needed.

Coffee.—The possibility of introducing coffee as a commercial crop.

General.—The best methods of breaking and using virgin soil and the subsequent handling, manuring, fertilization and rotation are questions that have a bearing on all crops and open a wide field for research work throughout the whole territory.

NYASALAND.

Owing to the limited number of scientific officers attached to the Department of Agriculture and the urgent demands on their time in connection with routine and advisory duties, it has not been possible to organize the work of the Department in such a manner as to allow of any members of the staff devoting their whole time to research; and such field and laboratory investigations as are undertaken are of necessity restricted, for the most part, to the solution of practical problems of immediate importance rather than to the study of fundamental principles.

The investigation work to which attention has been given in recent years is outlined below:—

Chemistry.—A soil survey of Nyasaland has been in course of progress and up to the present seven broad soil series have been defined. Much attention has been given to the use of fertilisers in tobacco cultivation; to the absorption of nitrogen by tobacco at different stages in the plant's growth; and to studies in nitrification.

Entomology.—Investigations have been carried out on "*Helopeltis bergrothis,* Reut," as a pest of tea; a new species of weevil, *Dicasticus mlanjensis,* Mshl; the development of the use of the indigenous plant "*Tephrosia vogelii*" as a contact insecticide; and the possibility of assisting to control Thrips on coffee by using fertilisers.

Animal Diseases.—Experimental work has been carried out on: The effects on cattle of the administration of various indigenous plants and plant products reputed to be poisonous; treatment of cattle infected by the liver fluke (*Fasciola hepatica*); treatment of sheep and goats infected by *Stilesia hepatica;* differentiation of infections due to *Theileria parva* and *T. Mutans* in cattle; test methods and drugs for treating Trypanosomiasis in cattle and dogs; best methods for mass treatment of animals for nematode infections, and *Tephrosia vogelii* for the treatment of animals suffering from external parasites.

Empire Cotton Growing Corporation.—The work of the Department of Agriculture has been much strengthened by the assistance given by the Empire Cotton Growing Corporation. The members of the staff of the Corporation appointed for service in Nyasaland are officially attached to the local Department of Agriculture, but carry out their duties as a self-contained body working in close co-operation with the Department—a form of organisation that has worked successfully. A large collection of types of cotton, obtained both locally and from abroad, has been tested and a number of promising strains have been retained for further trial. These strains fall into two main groups as regards their lengths, with staples about $1\frac{1}{8}$ in. and $1\frac{3}{16}$ in. respectively. Two strains have given particular promise, compared with the cotton in general cultivation, and are now being sown in bulk.

It has not been found possible, however, to confine the work to the cotton crop alone, and work is being done on practically every annual crop in cultivation in Nyasaland, though this work is merely subsidiary to the main objective, namely, the furtherance of cotton production in the country. In addition to the work being done on the crops themselves it has also been found necessary to attack various general agricultural problems, examples of which are: implements and their use, methods of training and handling working cattle, measures to check soil erosion, etc.

Two experiment stations have been opened and are in use in this work; the first, Makwapala, situated some ten miles from Zomba at an elevation of about 2,100 ft. above sea level, is representative of the middle elevations of the country between the 1,000 and 3,000 ft. elevations in which cotton is grown as a rainy season crop; the second, Port Herald, situated near the township of this name at an elevation of about 150 ft. above sea level, is representative of the low country of Nyasaland in which cotton is sown late in the rains and matures as a dry weather crop.

The high level station Makwapala, in addition to representing actual or potential cotton growing areas, is also representative to a considerable degree of the tobacco growing areas of Nyasaland; and in view of the fact that this crop and cotton are very suitable rotation crops, it is proposed to undertake, in conjunction with the Agricultural Department, a certain amount of work on tobacco from and including the 1927–28 season, which shall establish the relationships between the two crops, as well as providing a certain amount of information on the tobacco crop itself.

Work outside the stations has not so far reached any great proportions, but a commencement in distributing the seed of a select strain of cotton has been made in the current season. The work on rotation crops has, however, already commenced to bear fruit both with European and Native agriculture, and a considerable amount of seed stocks of crops useful as food crops has been distributed during the past two years. Sunn hemp, a legume useful both as fibre and

as green manure, has been advertised widely and promises to be a very useful addition to the country's crops.

In view of the serious losses from the depredations of insect pests the Corporation in 1923 appointed an Entomologist for the specific purpose of studying the bionomics of cotton pests found in Nyasaland, and of the red bollworm (*Diparopsis castanea*) in particular.

PALESTINE.

The chief winter crops are wheat and barley, and the chief summer crops durra and melons. Crops of smaller importance are beans, peas, lentils, kersenneh, sesame, grapes, figs, olives and almonds. The numbers of livestock in 1926 were: dairy cattle 59,000; working cattle 121,000; sheep 290,000; goats 841,000; buffaloes 4,000; camels 27,000.

The Department of Agriculture.

The divisions of the Department of Agriculture, Forests and Fisheries dealing with technical subjects are as follows: (1) Veterinary, (2) Agricultural Field Services, (3) Forests and Horticulture, (4) Entomological (including port plant inspection), (5) Agricultural Chemistry (including soil survey), (6) Meteorology, (7) Fisheries.

Veterinary and Live Stock.—The chief contagious animal diseases are anaplasmosis, anthrax, cattle plague, infectious pleuro-pneumonia of goats, goat scab, hæmorrhagic septicæmia, piroplasmosis, rabies, Theileria (Egypt Fever) and sheep pox. The Veterinary Division prepares and distributes serums and vaccines and also undertakes slaughter and isolation as preventive measures. Sheep and goats are treated with copper sulphate as a preventive against parasitic gastro-enteritis. Quarantine stations are maintained. Research work is carried out as far as possible, with particular reference to Theileria (Egypt Fever.).

The need for improving the local standard of all classes of livestock has been recognised and a central stud farm is being established at Acre, with five branch establishments. Pure bred animals are being imported from England and elsewhere.

Agricultural Experiment Stations.—Agricultural Experiment Stations are being established at Acre, Bersan, Jerusalem and Jericho and a programme of field research has been correlated with similar undertakings by the various colonising agencies. A local cotton growing association has been organised to continue an investigation of the possibilities of this crop.

Forestry and Horticulture.—Forest surveys and planting schemes are undertaken. A systematic collection and identification of forage plants has been organised and an enquiry set on foot to determine the actual carrying capacity of forest lands of different types. An analysis has also been made of the returns to goat farming on forest pasture with a view to limiting an excessive increase in this class of stock. Fourteen forest nurseries are maintained with over a million trees in stock. These include fruit and ornamental trees as well as forest trees.

Entomology.—A plant Inspection Service is maintained at ports of entry. Control of black scab of oranges is an important part of the entomological work. Research on fig scale is carried out. Almonds suffer severely from attacks of borer. The Department has made proposals for the foundation of a Locust Bureau for the Near East. The entomological laboratory also undertakes seed testing.

Agricultural Chemistry.—A soil survey is being carried out. Proposals are under consideration for the extension to Palestine of the investigation on the mineral content of pastures. Fertilizer experiments at the agricultural experiment stations will be correlated with the work of the Palestine Zionist Executive.

The Agricultural Experiment Station of the Zionist Organisation.

The Institute of Agriculture and Natural History of the Zionist Organisation has had, since 1921, an experiment station at Tel Aviv, which carries out research in plant physiology, plant pathology, plant breeding, horticulture, chemistry, animal and poultry husbandry and rural economics.

Biological research has related to birds beneficial and harmful to agriculture; physiological studies of citrus, almond and orange; weed control and seeds. In plant pathology, smut of cereals, black rot of cabbage, fruit rot of mushmelon, gumosis of orange, damping off of citrus and foul brood of bees have been the subjects of research. In entomology a list of insect pests has been compiled and their life histories roughly determined: special attention has been paid to the almond borer and to pests of tobacco. In addition to the central station at Tel Aviv there is a small field station for observational and control work at Ben Shemen and a small station for breeding beneficial parasites of orange pests at Petach Tikvah. In chemistry, investigations have been carried out on soils and on the composition of fruits and feeding stuffs. Agronomy work has been concerned with manuring, methods of tillage, times of sowing, green manuring, crop spacing, dry farming and rotations. In plant breeding pure lines of wheat and barley have been raised, selection work has been under-

taken, varieties of wheat (native and foreign) have been studied, milling and baking tests carried out; hybridisation work has been commenced. Variety trials have been carried out with barley, oats, leguminous crops, roots, oil seeds, durra, maize and tobacco. A Rural Economics Division has carried out an economic analysis of farms, an investigation of the cost of production of farm crops and a study of marketing and prices. Work in poultry husbandry has covered breeding, feeding, incubation, laying capacity, appliances, caponisation, egg preserving and diseases. Various investigations in horticulture, food preservation and animal husbandry are projected.

SIERRA LEONE.

The Research Division of the Department of Lands and Forests was formed at the end of 1924, so that research work, in so far as it refers to laboratory investigations, covers but a brief period. Much important work, however, has been accomplished by this Division since its establishment, and the following are the problems to which attention has been principally directed :—(*a*) Soil survey of Sierra Leone; (*b*) Oil palm investigations; (*c*) Retting trials with piassava; (*d*) General analyses (soils, palm fruits, grasses, copra, sugarcane, water, lime, manures, drugs, poisons, &c.).

Njala Experiment Station.—Field experiments and research are carried out at the Njala Experiment Station, situated in the Protectorate 106 miles up the railway, where also is the headquarters of the Division of Agriculture and where the following European staff reside :—Director of Agriculture; Provincial Superintendent of Agriculture in charge of Experimental Farm; Entomologist; Mycologist; Agricultural Instructor. There are also other sub-stations where crop trials and manurial experiments are carried out.

Manurial Trials.—The manurial trials conducted at the experimental stations have yielded interesting results. Practically all the soil of Sierra Leone is acid and in certain cases, such as cotton, this acidity has to be corrected before a good crop can be obtained; in other cases, crops such as citrus fruits, rice and oil palms seem to be able to withstand the rather high acidity. Since there are no local limestone deposits, it is thought that research should be directed to discovering crops suitable to the soil and climate rather than to attempting to change the soil to suit crops unsuitable for acid conditions.

Soil Survey.—As the greater part of Sierra Leone is covered with laterite soil—a type regarding which little is known and on which very little work has been done—a study of the soils was one of the first problems to engage the attention of the Agricultural Chemist. At

the West African Agricultural Conference held at Ibadan last March, general agreement was reached as to the desirability of adopting uniform methods of soil sampling and laboratory examinations to enable the work done in each of the West African Colonies to be readily comparable.

Shifting Cultivation.—It is the farming practice in West Africa to restore the fertility of the soil, not by manuring, but by allowing it to revert to bush and lie fallow for a period of 4–8 years, according to the density of the population and the area of bush land available. Unless the Government can introduce a system which will enable the same land to be farmed year after year, the soil will doubtless become further impoverished and result in decreased production of crops as time goes on. This question is being carefully studied at the Experiment Station at Njala, and it is hoped to evolve a rotation which will preserve the fertility of the soil without having recourse to the native method.

Rice Production.—Rice is the staple food of the people, and its cultivation, in the bush country, covers extensive areas of new land each year. Although the bulk of rice produced is " hill " or " dry " rice, an increasing quantity of " wet " or " swamp " rice is being grown. The Division of Agriculture is testing the suitability of different varieties for different parts of the Protectorate, and " swamp" rice, which a few years ago was confined to the Skarsies area, is now cultivated throughout the country.

The Oil Palm.—The oil palm presents, at the present time, the most serious economic problem before the Government, as its products, palm kernels and palm oil, which form from 70–80 per cent. of the total exports of the Colony, and are at present obtained from wild sources, are threatened with serious competition from the East, where the palm is being cultivated very successfully on a plantation basis. Investigations are being carried out at the Njala Station with different varieties, and the yields from different types are compared. Selection work is also carried out. It is hoped eventually to produce a good variety suitable for general cultivation in Sierra Leone.

TANGANYIKA.

So far, nothing in the nature of fundamental agricultural research has been done in the territory. The Agricultural Department does not possess the resources for this, and has been waiting for the re-establishment of Amani—not as a " glorified " agricultural experimental station, as its reports show it to have been when in the possession of its former owners, but as a research institution of the first order, making enquiries into the basic constitution, properties and activities of the soil and the plant, whose results will be passed on to the planter and farmer of every kind through the experimentation and teaching of Agricultural Departments.

For the reasons stated, agricultural enquiry in the territory has so far been mostly confined to investigations *ad hoc* rather than pure research. The experimental stations have shown what plants and their kinds are suited to the country, what is the relative value of those kinds, where they will flourish best, at what times of the year they should be planted, and how they should be treated while they are growing. The entomologist, the only officer of a technical kind attached to the Agricultural Department until recently, has investigated the pests which attack the principal crops of the territory and the means of dealing with them, and has given advice both in formal reports and the public press as to the measures to be taken against them, both by planters and farmers and by the State. The results of all these investigations appear regularly in the Annual Agricultural Reports.

This work is already being extended by means of co-operative field experiments with planters (particularly for coffee in the Northern Province) and through agricultural substations, partly or entirely supported by Native Council funds, in which the better and improved crops and their kinds, already tried in the main agricultural stations, undergo local trial and planting for increase if they are successful. It is to be further extended by the provision on the staff of the Agricultural Department of an agricultural economist, a mycologist and an assistant entomologist ; and later, it is hoped, a chemist and assistants for the work of the first two of these. With such help the work of district agricultural officers (the field officers of the Department, in the remoter areas responsible immediately to a Senior Agricultural Officer in charge of an Agricultural Circle, for the decentralization that is requisite) will lose what has been diffuse in its character in the past, and be brought to definite *foci*. These officers will constitute the executive extension of the investigations and activities of the specialists for giving planters and farmers better plants and husbandry and the knowledge required for growing their crops in the best places and keeping them healthy.

It has been shown that all this work is based upon the results of fundamental research. What are the important problems, and what this research is to be for East Africa, are for Amani to decide.

TRINIDAD AND TOBAGO.

Organisation.—The research work of the Trinidad Department of Agriculture is carried out at :

1. The Royal Botanic Gardens and adjacent St. Clair Experiment Station. The latter is now mainly used for plant nursery work. Distribution about 150,000 plants. The Herbarium dates from about

1840 and is very complete. There is a branch Botanic Station in Tobago.

2. River Estate, about 1,500 acres, run as a commercial estate for cacao (principally), fruit, limes, coffee, &c., and used as a cacao experiment station.

3. St. Augustine Experiment Station—140 acres, where seedling canes are bred, imported canes tested, and experimental work done on cane, cassava, cotton, yams, cover crops, &c.

4. The Government Farm, 350 acres, for the supply of milk to Government institutions and improvement of the Colony's live stock. Thoroughbred stud animals, horses, donkeys, cattle (Indian and Holstein), pigs, Swiss goats are kept, also poultry.

A branch farm is maintained in Tobago.

Staff.—The principal officers are :—Director, Entomologist, Mycologist, Agricultural Chemist, Government Veterinary Surgeon (also in charge of the Farm), Cacao Agronomist, Superintendent and Curator Botanic Gardens, Managers of River Estate, St. Augustine Experiment Station and the Tobago establishments.

Principal Crops.—The chief crops are cacao, sugar and coconuts.

Sugar Cane.—The great need in most Trinidad cane soils of increased quantities of organic, humus-containing manures is becoming recognised. In addition to making ordinary pen manure in covered and field pens, the Mauritius system is employed in which by using large quantities of chopped grass a comparatively few animals can produce a very large amount of good quality manure in a short period.

In 1926 the first experiments were made in preparing " Adco " manure, twenty tons of the imported materials being used on sugar cane trash, grass, &c. Trials at St. Augustine Experiment Station and on sugar estates were satisfactory.

Owing to concentration on organic manures artificials are less used. The Usine Ste. Madeleine, however, conducts very useful manurial experiments and publishes its results in an Annual Report.

The Government Sugar Experiment Station at St. Augustine has as its main duty the breeding of Trinidad seedling canes, started in 1917, although a few had been bred many years before. The testing and selection at the station occupies at least 5 years, after which the best canes are distributed to the principal estates for trial under their conditions of soil, climate, etc. The Station is also used for testing new canes imported from Barbados, Hawaii, Mauritius, Louisiana, St. Croix, Java, India, &c.

As part of the Froghopper Investigations (see below) extensive experiments have been made at the Station during the last two years with cover and rotation crops, some of the best of which are Bengal

Bean (*Stizolobium aterrimum*), Sunn Hemp (*Crotalaria juncea*), *C. usamorensis, Tephrosia candida, T. purpurea and Canavalia* sp.

The chief diseases and pests are root disease: *Marasmius sacchari*; mosaic disease (this was first recognised in 1920).

Sugar Cane Froghopper.—A special Committee was set up in 1925 for the investigation of this pest with a fund of £5,000 per annum for five years, half of which is provided by the sugar companies and half by the Government. Work is carried out on the life history, methods of eradication, relation to enemies and parasites (including fungi), correlation between soil reaction and blighting, etc. It appears that an agriculturally imperfect condition of the soil is favourable to the development of froghopper infestations in years when the general climatic conditions are suitable.

Rubber.—On certain plantations the results with Hevea have proved equal to those obtained on average estates in the East and the development of Hevea cultivation is recommended. Hevea is not subject to any serious troubles. The South American Hevea leaf disease (*Melanopsammopsis Ulei*), so devastating in Surinam and British Guiana, occurs, but usually only on young plants, mature trees escaping injury.

Livestock.—To assist this industry Government Farms are maintained in Trinidad and Tobago. At both thoroughbred stud animals are kept.

Imperial College of Tropical Agriculture, Trinidad.

Research is an important function of the Imperial College of Tropical Agriculture; the following is a brief summary of the work being carried out.

Botanical.—A preliminary investigation of the cytology of both the coconut and cacao is being undertaken.

Breeding work is carried out on bananas with the object of obtaining a marketable fruit that will stand transport and will at the same time prove more resistant to Panama Disease than the Gros Michel.

Sugar Cane.—A Committee has been formed to investigate the Froghopper Blight on sugar-cane, a pest that is causing immense damage to the crop in Trinidad, and has necessitated what is in effect a complete soil survey of the whole of the sugar cane area of the Colony. A commencement has been made into a study of the genetics of the sugar-cane as distinct from the plant breeding methods usually employed at present.

The sugar technologists are investigating the various impurities in the cane juice and in particular the significance of the phosphate content. The bye-products of the cane factory are also receiving special attention.

Other Crops.—Particular attention is being paid to the breeding of types of "heavy leaf" tobacco suitable for the local market. A detailed study is being made of different types of commercial bananas under field conditions, this work being a necessary corollary to that of the Botanical Section. Cover crops are being investigated in detail and an attempt is being made to discover a suitable alternative or "resting" crop for sugar-cane. Work on cotton is now left to a great extent to the officers of the Cotton Research Station of the Empire Cotton Growing Corporation which is situated adjacent to the College.

Plant Diseases and Pests.—The Mycological Section is an important one as diseases of plants possess an even greater significance in the tropics perhaps than they do in the temperate and sub-tropical regions. The control of such diseases as the withertip of limes, which is devastating large areas in this part of the world, is being considered. A series of investigations into the cause and control of certain widely spread and destructive diseases of the coconut, such as the so-called "Wilt disease," has been commenced and affords a very wide field for research. So far as pests are concerned, a study of the various races of cotton stainer (*Dysdercus*) was commenced and a disease of bees has been investigated.

Economics.—The economics of tropical agriculture offers a wide field for investigation as comparatively little has yet been done in this direction. The methods of field costings employed in the temperate zone are not likely to prove applicable to the tropics, and it seems likely that a separate system, or systems, will have to be worked out. An enquiry into the various systems of co-operative credit societies suitable for peasant farmers has been commenced.

Trinidad is an admirable site for an Institution designed for research in advanced tropical agriculture. The climate is good for the tropics and the nights are usually cool. A very large variety of crops are already grown on a commercial scale and can be studied on the spot. Most other tropical crops have already been proved to grow well also and can, therefore, be cultivated for purpose of study as required. In addition Trinidad is centrally situated so far as communications are concerned and is served by several lines of mail steamers. It has the further advantage in that it lies in close proximity to the Spanish Main and to the islands of the Carribbean which possess distinctive climates and often specialise in particular crops.

UGANDA.

1. Survey of Agriculture.

Cotton.—This crop is the most important one in the country and represents approximately 90 per cent. of its exports. Any crop rotations suitable for general adoption must hinge on cotton as the

main crop, and these are limited to food crops and oil seeds, such as bule (*Eleusine coracana*), beans, sweet potatoes, maize, groundnuts and sim-sim. Bule is an excellent crop to follow cotton throughout the areas inhabited by the grain-eating tribes and ensures a plentiful supply of local food.

Coffee.—*C. arabica* is the most important crop grown by European planters and at the higher altitudes is fairly successful. *C. robusta* grows splendidly over large areas of the Protectorate and is being largely planted by natives. European planters in some districts are also planting *C. robusta*, and in a few years exports of this type of coffee will exceed those of *C. arabica*.

Rubber is next in importance to coffee on European plantations, having originally been interplanted amongst the coffee. Most of the coffee has now been taken out and the Para rubber left as the main crop.

Sugar.—Sugar cane grows luxuriantly and a large factory for the turning out of white sugar has been in operation for the past three years. All the sugar is sold locally and in neighbouring territories. Power alcohol for which there is an expanding local market, is made from the molasses at this factory.

Oil Seeds.—Groundnuts and sim-sim are widely cultivated and their production is encouraged. Both provide suitable rotation crops for cotton, and are excellent native foodstuffs which can be exported if not required for local consumption.

Food Crops.—Bananas and plantains are the staple food crop in Buganda Province. Numerous varieties are cultivated and grow well, so that food is provided with a minimum of effort. In other provinces grain crops are the staple food, the most important being *Eleusine coracana*. Maize and sorghums grow well and sweet potatoes are largely cultivated. Cassava cultivation is pretty general as an extra food supply in cases of scarcity.

2. Cotton Botany.

The cotton being produced at the present time in Uganda, more especially that from N 17 seed, is of excellent quality and both brokers and spinners alike appear satisfied. Careful work is necessary to ensure that the quality does not deteriorate as a result of natural crossing in the field with bad strains which are still existent. Purer strains are being produced and great care is taken in their propagation from small quantities to the mass for distribution to growers.

The question of quality is very hard to test under laboratory conditions, and samples are sent home yearly for brokers' report and spinning tests, and the results of these are used as a guide in selection. In the laboratory regularity and length of staple, breaking load and hair diameter are found and these are correlated with the results of the tests in England.

The increase of yield is the great problem confronting the grower of cotton in Uganda; although variation in yield is largely due to climatic conditions which are uncontrollable, yet there is no doubt that the yield can be increased by improved cultivation and by improved strains.

Selection Work.—The aim of this work is the production of pure strains of improved yield and where possible resistance to disease and insect pests. Five years' work is necessary from single plant selection in the first year to bulking in the fifth year.

Data from progeny rows are used to find how the yield of the crop is built up and by correlation of growth, flower, shedding and bolling curves with meteorological records the effect of climate on the crop is determined.

Cross Breeding.—A number of crosses F1, F2, and F3 generations are being dealt with, but the isolation of a homozygous strain is likely to be a very long process and not much stress is laid at present on cross breeding until such time as plenty of European workers are available.

New Varieties.—New varieties and strains are obtained from other countries where a similar type of cotton is cultivated, and these are grown under close observation for comparison with existing strains.

3. Entomology.

Cotton.—The status of each of the pests already known to be present in Uganda is being determined as well as the seasonal prevalence of each in relation to the time of planting the cotton. Work is in progress on the transmission of the various boll diseases by insects and some data have already been obtained, indicating that *Dysderous spp.* are very efficient as inoculating agents of *Nematospera gossypil,* the fungus causing internal Boll Disease.

Coffee.—The "root mealy-bug" (*Pseudococcus lilacinus* Ckll.) is closely associated with the fungus *Polyporus coffeae* Wakef., and it is not yet certain which is of primary importance. The combination of the two is serious in a coffee field and work on the control of this disease is being carried out.

Experiments bearing upon the balance between the coffee berry borer (*Stephanoderos hampei*) and its parasite have been commenced.

4. Mycology.

Cotton.—The status of each of the diseases already known to be present in Uganda is being determined as well as the seasonal prevalence of each in relation to the time of planting the cotton. For work on the transmission of the various boll diseases by insects see under Entomology.

Coffee.—Most of the diseases of this crop in Uganda are largely controlled by attending to general cultivation, and such methods of

control as spraying are ruled out on account of expense. *Memileia* (" Leaf Disease ") in Uganda is largely due to previous overbearing having weakened the trees. On the other hand the root diseases due to *Sclerotium bataticola* and *Armillaria mellea* are merely sporadic in occurrence and no methods of prevention have been worked out.

Rubber.—Brown Bast is becoming the most serious disease of rubber in Uganda, because the trees are more or less permanently injured by this disease. The Keuchenius method of treatment has proved in the East the only method giving satisfactory results, and has been advocated in Uganda since about 1920.

5. Agricultural Chemistry.

Soil Problems.—Among the chief of the general problems affecting soils in Uganda is that of the deterioration of the soil owing to erosion by rain wash and exposure to the sun. Both ultimately result in the disappearance of the valuable humus, leaving a residue of clay and fine stones. This problem is under investigation by the chemist, who is endeavouring to work out systems of drainage and cultivation to reduce the deterioration of the soil to a minimum.

The problem of manuring crops in Uganda is limited, as only green manures, artificial farmyard manure (" Adco ") and lime are available for use. Local minerals will be investigated with regard to their possible value as fertilisers.

WESTERN PACIFIC (TONGA).

The staple crop is coconuts.

The European staff of the Department of Agriculture includes a Director of Agriculture who is also the Manager of the Government Farm, an Inspector for Rhinoceros Beetle and a Copra Inspector.

The two most serious problems are the improvement in the quality of copra and the extermination of rats on plantations.

Research has been carried out on Rhinoceros Beetle and Spathe Moth on coconuts ; and bunchy top, weevil (*Sphenophorus sordidus*), and fruit caterpillar of bananas. In addition experiments have been carried out on cover crops and soil renovating crops at the Government Farm.

WINDWARD ISLANDS (GRENADA).

Agricultural Organisation.—In 1926 a scheme of Agricultural co-operation between Grenada and the colony of Trinidad and Tobago was put into operation.

Agricultural Exports.—The chief crops are cocoa, nutmegs and mace.

Cocoa.—Cocoa diseases such as black pod and canker (both due to *Phytophthora Faberi*) are relatively scarce. On the other hand Algal diseases (*Cephaleuros mycoidea*) occur on exposed trees under poor conditions. Thrips (*Heliothrips rubrocincte*) has long been known and at times does considerable harm. The cacao beetle (*Steirastoma depressum*) occurs, as also mealy bug, associated with black ants.

The principal disease of nutmegs is root disease, due to *Rosellinia Pepo*, the mode of treatment of which is well known.

The dwarf coconut from Malay is being experimented with. The principal disease is red ring due to the nematode (*Aphelenchus cocophilus*). The scale (*Aspitiotus destructor*) is also fairly widespread.

ZANZIBAR.

The special problems in which Zanzibar is interested are as follows :—

Reduction of Costs of Production.—(*a*) By association of land-owners, (*b*) by improved methods of cultivation, (*c*) by organization of transport.

Improvement in Quality of Produce.—(*a*) By better methods of preparation, *e.g.*, artificial drying, (*b*) by grading.

Organization of Marketing.—(*a*) Supervision of dealers' transactions, (*b*) public auctions providing direct channel between producer and exporter.

Agricultural Credit.—Institution of some form of Government credit to replace borrowing from merchants.

Prevention of Predial Larceny.

Stabilisation of Markets.

Methods of Regeneration in Plantation Industries.

SUDAN.

Scientific work in connection with agriculture in the Sudan is under the joint control of the Director of Agriculture and Forests and the Director of the Wellcome Tropical Research Laboratories, and is carried on at the Wellcome Tropical Research Laboratories, Khartoum, the Botanical and Plant-Breeding Station, Shambat, Khartoum North, and the Gezira Research Farm, Wad Medani, (Gézira).

1.—Wellcome Tropical Research Laboratories.

Since the inception of the Wellcome Tropical Research Laboratories in Khartoum, investigations relating to chemical and entomological problems connected with agriculture have been undertaken by the respective sections of the Laboratories. These sections, although under an ægis distinct from the Department of Agriculture, have always maintained a close liaison with that Department, thus permitting of co-operation in both field and laboratory experiments.

The development and expansion of agriculture in the Sudan, more especially in connection with cotton growing, resulted in chemical and entomological laboratories being eventually established at the Research Farm in the Gezira, where the various problems connected with irrigated cotton have been studied.

To serve the needs of the Northern Sudan an entomological station has been established in the Berber Province, and last year a similar station was started at Talodi in the Nuba Mountains Province for the purpose of studying and controlling the pests of rain-grown cotton. The Talodi station will also be responsible for studying the bionomics of the tsetse fly *G. morsitans* and organizing control measures for a tsetse fly belt in the Koalieb Hills of this district.

Chemistry.—Chemical research in connection with agriculture has centred mainly on the agricultural chemical problems connected with cotton growing in the Gezira. Much of the recent work has been carried out at the Gezira Research Farm, where it is possible to conduct properly controlled experiments and to apply the results in field experiments on a larger scale. Assistance is rendered as regards staff and advice by the Empire Cotton Growing Corporation and Rothamsted Experimental Station.

The investigations cover a wide field. The area surveyed by the chemical section is interesting if not unique by virtue of the soil characteristics determined. The researches of the chemical section include a soil survey of the north and south areas of the Gezira, analyses of the soil at varying depths, investigations on the alkali problem, distribution of salts in the soil, movement of salt in soil under irrigation, moisture equivalents, rate of evaporation from soils, humus determination, soil permeability, nitrate content, influence of moisture on nitrification, seasonal variation of nitrate content, relations between salt content and yield, and application of various fertilizers and chemicals and their effects on soil alkalinity.

Entomology.—The work of the entomological section has centred mainly on the study of the bionomics and control of pests attacking cotton, dura and other crops. A vast amount of data has been collected regarding the seasonal incidences of the pests, and their bionomics and the control measures advised have received the support of the Government in the form of special ordinances and regulations.

Investigations have been carried out on the origin and distribution and bionomics of the Pink Boll-worm *Pectinophora Gossypiella*, the Sudan Cotton Boll-worm *Diparopsis castanea*, the Cotton Aphis *Aphis gossypei*, Cotton Thrips *Heliothrips indicus*, Cotton Stem-borer *Sphenoptera neglecta*, Cotton flea beetle *Nisotra uniformis*, Cotton stainer bug *Dysdereus superstitiosus*, Spiny or Egyptian Boll-worm *Earias insularia*, Migratory locust *Schistocerea migratoria*, White Ants *Termitadæ*. Special attention has been directed to the possible parasitization of some of these insect pests as a measure of control.

The entomological section also assists in the sunning of cotton seed as a control measure against the boll-worm, and advises the Veterinary Department in regard to control measures against blood-sucking insects attacking livestock.

2.—Shambat Botanical and Plant Breeding Station.

Plant Breeding. —Attention is chiefly directed to *cotton*, with particular reference to (*a*) the Gezira Scheme, and (*b*) Southern Rain Cotton Area.

As regards (*a*) it is recognized, particularly after the experience of the last two seasons, that " Sakel " has given a very satisfactory result in the Gezira. Attention is therefore being concentrated upon : (1) Selection and breeding up of single-plant lines of improved " Sakels." (2) Increasing the vigour of the Sakel types by hybridisation with Sea Island, and stabilization of the derivatives. (3) Inducing earliness in crop production by hybridisation with Afifi and Ashmuni types. (4) Introduction and selection of Sea Island types after local modifications, with the idea of replacing the Sakel type by a more effective one, with lint of superior quality, but with similar spinning characteristics.

Tests of existing established strains of Sakel and similar types of cotton are also being carried out on a field-plot scale to enable decisions to be taken as to the most profitable strains to be grown.

As regards (*b*), the Southern rain area presents a different series of problems. American varieties would appear to be most likely to succeed, and the locally established type has given good results. This local type is, however, very decidedly mixed. The lines along which work is proceeding in this case are therefore :—

(1) Introduction and extensive trials in field-plots of new and different American types.

(2) Selections from the local type in an attempt to fix a strain combining its best points.

(3) Selection from amongst newly imported types, after they have been subjected to the changed environmental conditions.

Standardized cotton variety tests are being carried out at the following places : *Egyptian types*—Shambat, Gezira Research Farm,

and Barakat Seed Farm. *American types*—Kober (Khartoum North), Shendi and Nueis (Berber Province), Sabonabi and Ghati (Fung Province), Talodi and Kadugli (Nuba Mountains Province).

The number of families in the various selection, pure line and hybridization plots will be about 250.

In addition to the above work on cotton, the Plant-Breeding Section assists in the propagation of the bulk seed supplies, including the supervision of a nucleus roguing plot in the Shambat area.

Along with the plant-breeding work is carried out a systematic developmental study of the cotton plant under local conditions, particular attention being paid to the effect of extremes of temperature and humidity as recorded by the plant itself.

Other crops are also studied, particularly *Dura*. A collection is being made of all available local types, and the more promising of these are being tried out in observation plots, and in variety-test plots. Single plant selection is also being made use of to obtain pure plots of uniform behaviour.

The two most important lines along which work is proceeding are: (1) Provision of suitable types for the areas in which the rainfall is very precarious, (2) provision of types suitable to the irrigated area in the Gezira.

Maize, Dukhn and Wheat are also receiving attention. New kinds of maize and wheat have been imported, and single plant selections are being grown in the case of dukhn.

Fibre crops other than cotton are being investigated, and general plant introduction work is being carried on in collaboration with the Government botanist.

A Nursery Section deals with the propagation of introduced types of trees, shrubs and other plants, and a considerable amount of young stock is distributed to various provinces each year.

Pathology.—Certain diseases are receiving particular attention, notably Blackarm Disease of cotton, where a striking connection has been demonstrated between the temperature of the soil and the incidence of the disease on seedling cotton. This, in turn, involves the effect of rain during the sowing season in relation to the cooling of the soil. An extensive series of experiments is in progress with carefully arranged controls, the results of which may be of immediate practical importance.

Other work on this parasite and its host plant is also in hand, involving developmental observations and an examination of the reactions exhibited by plant tissues in relation to disease incidence. In particular, the degree of acidity of the cell sap has been demonstrated to vary under different conditions of growth and to be connected with the incidence of disease.

Other diseases which are receiving detailed study are a *Root-rot disease of Cotton and Lubia*, in which temperature relations again

play an important part, and diseases of *Melons* and *Tomatoes* which are causing very considerable losses.

Physiology.—A continuous series of records is carried out on a small plot of *cotton* specially selected for the purpose. Records include accurate data as to growth rate, flowering rate, increase in dry weight, and leaf area combined with a parallel series of observations on the meteorological conditions. This series is duplicated at the Gezira Research Farm under the direction of this section.

A detailed investigation is in progress into the physiology of *gum production*, which shows that the phenomenon is not the result of parasitic action. The changes which occur in the plant tissues have been followed consecutively throughout the season, and the new knowledge thus obtained is expected to have useful application in bringing the actual production of gum under some sort of control. Improved methods of tapping are being tried out.

3.—Gezira Research Farm, Wad Medani.

This station has well-equipped laboratories for chemical, botanical and entomological work. Apart from the more purely scientific research carried out in these laboratories, the programme of agricultural experiments has been designed to throw light upon the various problems which are encountered in connection with the development of the Gezira Irrigation Scheme. A carefully arranged programme of experiments, with provision for the necessary replications, has been arranged, and accurate observations are made in connection with the following subjects: (1) Duty of irrigation water, effect of varying quantities and periods of application. (2) Rotation of croppings. (3) Dates of sowing. (4) Spacings. (5) Manuring, quantities and dates of application. (6 Variety tests of cotton and dura. (7) Climatic conditions in relation to crop growth. (8) Tillage operations, effects of light and heavy tillage, periods of cultivation, &c. (9) Behaviour of the soil under continued irrigation and cropping—effects of tillage operations and fallow in this connection. (10) Livestock. Breeding, feeding and general economics of livestock farming in connection with cotton growing on irrigated land.

Appendix.

EMPIRE COTTON GROWING CORPORATION.

The scientific work upon which the Corporation are engaged can be divided into two main heads: (*a*) Fundamental Research and (*b*) Investigations chiefly in connection with local problems.

(*a*) **Fundamental Research.**

A sub-committee, on which some of the most prominent scientific experts of the country served, after considering the respective possibilities of subsidizing existing institutions or of establishing a special station, and after weighing the merits of all the possible locations therefor, recommended the establishment of a Central Cotton Research Station in Trinidad as likely to afford the best facilities for fundamental research on the cotton plant, its pests and diseases. The station was accordingly opened at St. Augustine in 1926. The purchase of the necessary land, comprising some 60 acres, the erection and equipment of laboratories, and the provision of staff houses, has involved to date an expenditure of some £16,000. The annual recurrent expenditure is estimated at about £7,000.

A start has been made with two departments in the first instance —a Genetical and a Physiological. In addition to research on such basic problems as boll shedding and the causes underlying the production of immature fibre, it is hoped to refer to the station problems that arise in any particular cotton growing area, the solution of which may have an important bearing on yield per acre and lint quality in a number of different countries.

The Genetical work which the Corporation had been carrying on in St. Vincent since 1921 has been transferred to the Research Station.

(*b*) **Investigational Work.**

Work on problems common in some cases to a number of the cotton growing areas, and in others of local importance only, is being carried out simultaneously both at home and abroad.

(i) *Work in England.*—Subsidies have been allocated for a period of five years in the first instance, to four institutions in England—Cambridge University, Manchester University, the Imperial College of Science and Technology, and the Rothamsted Experimental Station. Not only are these four foundations always ready to arrange courses suited to the individual needs of the men sent there for advanced training by the Corporation, but they welcome them on their return from abroad, and give them facilities for attending refresher courses or carrying out any investigations which their work abroad may have suggested to them, but which can be more easily carried out at home. In addition, each institution has detailed a member of its staff to specialize in those aspects of his particular subject which are of importance in cotton growing. By this means it is hoped that members of the Corporation's staff

abroad will be kept in close touch with work that is being carried on at home, and thus be able to apply to their particular problems any advance recorded in the knowledge of the principles underlying them.

To mention a few typical instances of the work which these institutions are carrying out for the Corporation, the School of Agriculture at Cambridge is testing the feeding value for poultry and pigs of bulrush millet, one of the best rotation crops for cotton in Nyasaland, but which, without a higher market value than it at present commands, cannot be exported at a profit. At Manchester, in collaboration with the Corporation's entomologist in Nyasaland, the Entomological Department is endeavouring to detect and isolate the attractive principle in the cotton plant which leads to attack by the red bollworm.

The Imperial College has been at work on fungi causing boll disease and on an investigation into the effect on the germination of cotton seed, both healthy and damaged by insect attack, of treatment with sulphuric acid, while at Rothamsted the peculiarities of the Gezira soil are being investigated, using large samples sent home from the Sudan for that purpose.

Members of the staffs of all four foundations have paid visits to cotton growing areas to enable them to deal more effectively, in the light of a knowledge of the conditions under which cotton is grown, with enquiries received from abroad.

In this connection it may be mentioned that the Corporation would welcome enquiries from Directors of Agriculture in the cotton growing dependencies and colonies, or from members of their staffs, and they may rest assured that all possible steps will be taken to elucidate the problems submitted.

Before passing to the consideration of the work in progress abroad, a tribute must be paid to the British Cotton Industry Research Association, the experimental department of the Fine Cotton Spinners and Doublers Association, the Oldham Master Cotton Spinners Association and to the Liverpool Cotton Association, for the help they have rendered in arranging for brokers' reports and in carrying out spinning tests on samples of cotton sent home for the purpose by the Indian Central Cotton Committee, various Directors of Agriculture, and members of the Corporation's staff. The Corporation will be only too happy to do all in their power to assist cotton breeders by arranging spinning tests.

(ii) *Work Abroad.*—The Corporation have established stations in most of the cotton growing countries in the Empire at which to carry out, *inter alia,* plant selection, seed multiplication, optimum time of sowing, manurial and spacing experiments, and rotation crop trials. The cost of running these stations is shared between the Corporation and the local Government.

In *Australia* a grant of £3,000 per annum for five years has been made to the Commonwealth Government to assist them in establishing cotton experiment stations. Work has now been in progress at Biloela in Queensland for the last two seasons. The area of the

station consists of 417 acres, of which 135 acres have so far been brought under cultivation.

South Africa.—The Corporation's chief station is situated at Barberton, where Mr. Parnell has succeeded in producing a cotton highly resistant to Jassid. Subsidiary stations have been established at Candover in Natal, and Bremersdorp in Swaziland. A number of farmers in various areas are also working in conjunction with the Corporation's staff in testing out special strains of cotton.

Southern Rhodesia.—A Plant Breeding and Experimental Station has been opened in conjunction with the Southern Rhodesian Government at Gatooma, between Bulawayo and Salisbury.

In *Nyasaland* there are two experimental stations so situated that one is typical of conditions in the settled areas, the other of those in the chief native producing districts.

In the *Sudan* work to which the Corporation contributes is being undertaken at the Shambat Station, near Khartoum, in connection with the selection, purification and propagation of cotton and other field crops already established in the country, while new strains and varieties of such crops are being introduced and tested. In addition, research is being carried out into the underlying principles which influence the growth and yield of cotton and other crops, and their resistance or susceptibility to disease.

In *Northern Rhodesia* a cotton specialist appointed by the Corporation has been engaged in working in conjunction with the local Agricultural Department in organizing a cotton-growing industry amongst the settlers. The Government are establishing an Agricultural and Veterinary Station, at which a former member of the Corporation's staff will be in charge of the agricultural side of the work.

The *Nigerian* Government having requested the Corporation to establish a seed farm in the Northern Provinces, at which improved types of cotton can be multiplied up for distribution to the native cultivators, a station has been opened at Daudawa.

In *Fiji* the Government have established an Experimental Station, at which a cotton specialist appointed by the Corporation is working on seed selection.

Detailed reports on the work carried out last season at the Experiment Stations in Queensland, the Union of South Africa, Swaziland, Southern Rhodesia, the Anglo-Egyptian Sudan, Nyasaland (including also 1924–25), Nigeria, and St. Vincent, as well as at the Government Station at Serere in Uganda, were published by the Corporation in a book entitled "Reports received from Experiment Stations, 1925–26."

Copies of this publication were circulated in January, 1927, to all persons likely to be interested, including the Agricultural Departments in the cotton-growing Dominions and Colonies. A limited supply is still available at the Corporation's Office, Millbank House, Westminster, S.W. 1.

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